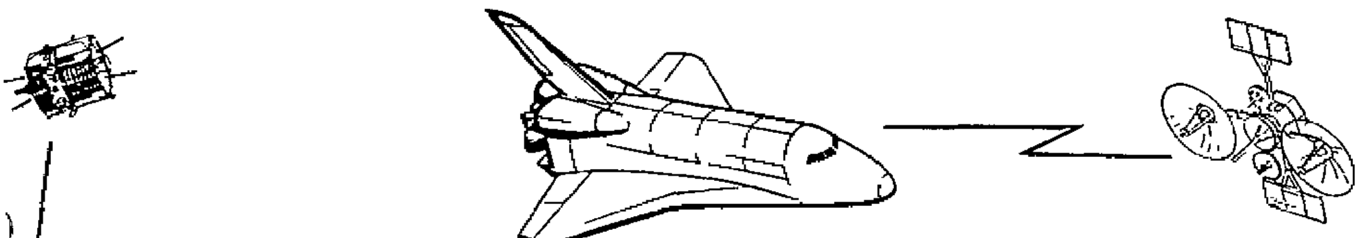
SPACE TRANSPORTATION SYSTEM PAYLOADS MISSION CONTROL STUDY

CR-151139

CONTINUATION PHASE A-1

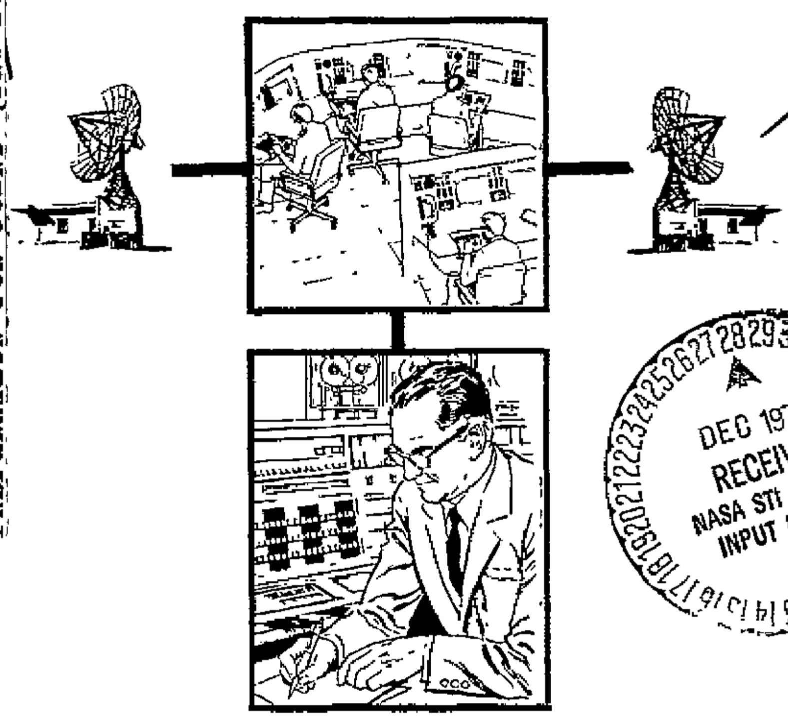
VOLUME II-C



FINAL STUDY REPORT FOR TASK 3

IDENTIFICATION OF JOINT ACTIVITIES AND ESTIMATION OF RESOURCES IN PREPARATION FOR JOINT FLIGHT OPERATIONS

CONTRACT NAS9-14484



Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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November 1976

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FINAL REPORT
FOR
STS PAYLOADS MISSION CONTROL STUDY
CONTINUATION PHASE A-1

TASK 3
IDENTIFICATION OF JOINT ACTIVITIES AND ESTIMATION OF COMPOSITE RESOURCES IN PREPARATION FOR JOINT FLIGHT OPERATIONS

NAS9-14484 NOVEMBER 1976

Prepared for
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FOREWORD

This document represents one Section of the FINAL REPORT for the STS PAYLOADS MISSION CONTROL STUDY CONTINUATION PHASE A-1, prepared by TRW Defense and Space Systems Group under Contract NAS9-14484, with NASA, Lyndon B. Johnson Space Center. The complete list of documents that comprise the FINAL REPORT of this Study is as follows:

- Volume I - Integrating Summary Report
- Volume II-A - Study Task 1 - Joint Products and Functions for Preflight Planning of Flight Operations, Training and Simulations
- Volume II-B - Study Task 2 - Evaluation and Refinement of Implementation Guidelines for the Selected STS Payload Operator Concept
- *Volume II-C - Study Task 3 - Identification of Joint Activities and Estimation of Composite Resources in Preparation for Joint Flight Operations

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TABLES

FIGURES

FIGURES (Continued)

3.0 TASK 3 - IDENTIFICATION OF JOINT ACTIVITIES AND ESTIMATION OF COMPOSITE RESOURCES IN PREPARATION FOR JOINT FLIGHT OPERATIONS

The original study placed emphasis on STS Payload Mission Control Concepts for real-time flight operations. The other key operational requirement is to prepare for the real-time operation, i.e., flight planning, training, simulations, and other flight preparations as necessary.

This task will identify joint STS-Payload activities for the preflight phase, develop activity sequences and organizational allocations and apply traffic model and experience factors to establish composite man-loading for joint STS-Payload activities in preparation for flight operations of STS flights from 1980 through 1985.

3.1 INTRODUCTION

The objective of this study task is to identify joint preflight activities and develop estimated composite joint resources required to accomplish preflight activities in preparation for STS-Payload flight operations, training and simulations based on given flight traffic and payload assignment models.

In this part of the study, joint activities are defined as those flight preparation functions which involve both the STS Operator and the Payload Operator. This is the integrating phase of activities associated with flight preparation.

The integrated portion of flight preparations should start at two years prior to the launch of each flight so as to provide a standard basis for scheduling activities. It will be necessary to obtain data concerning the individual planning activities of both the Payload Operator and the STS Operator before the joint preflight planning can begin.

A considerable proportion of the efforts of the integrating phase of flight preparation will involve combining or merging various plans, data and information and the validation of the individual inputs received from both the STS Operator and Payload Operator. This will insure the compatibility and the operational efficiency of the combined operation in light of the separate requirements and the constraints of the STS/Payload elements.

The goal of the joint flight preparation activities is to insure an optimum approach to maximizing the total mission accomplishment of the combined STS-Payload Operation while at the same time minimizing the expenditure of flight preparation resources.

In the approach to identifying joint activities and estimating resources for joint preflight preparations, the activities have been evaluated in relation to four types of flights: (1) Spacelab 7-Day Flights; (2) Spacelab 30-Day Flights; (3) Automated Earth Orbiting (AEO) Flights; and (4) Planetary Flights. In estimating resources, considerable emphasis has been placed on assessing the relative complexity of these four flight categories.

In establishing relative complexity factors the following were considered:

a. Although a wide variation in the range of complexity exists among the various missions of a given flight type, especially in Automated Earth Orbiting and Planetary Missions, the impact of mission variations on the joint portion of the flight is minimal. Thus, it was relatively easy to establish a mission of "average complexity" as the basis for resources estimation.

b. In so far as the four flight types are concerned, the AEO, Planetary, and 7-Day Spacelab Flights are comparable in duration and complexity for the joint portion of the mission. The 30-Day Spacelab Flight requires considerably more preflight preparation in the areas of consumables planning, crew timelines and other factors affected by the extended duration of the combined STS-Payload Flight.

3.1.1 Relationship of Study Task 1 to Task 3

The results of Task 1 were used as major input to the development of Activities, Tasks and Subtasks formulated in Task 3 and formed a basis for the Task 3 composite Joint Resources analysis. In Task 1, specific functions, products and facilities needed to prepare for flight operations with Spacelab, Automated Earth Orbiting and Planetary Payloads, respectively, were analyzed in some detail, and essential elements identified. Generic tasks, products and facilities were identified in Task 1 that are required to perform specific flight operations, ground based control/support efforts and the training and simulations necessary to certify STS and Payload onboard/ground personnel for the flight. For example, Tables 1.4-1 and 1.4-2 of Task 1 Final Report described applicable generic, Joint Planning Products such as Flight Requirements, Trajectory, Timeline, Crew Procedures, Flight Rules, etc., and gave specific examples. Table 1.4-3

described those Joint Planning tasks and products common to all flight types -- i.e., Spacelab, Automated Earth Orbit or Planetary. Table 1.6-1 described facilities required and how they would be used, and Tables 1.6-2 and 1.6-3 showed current capabilities and state of readiness for use (primarily Training, Simulations and Computations facilities).

All of the data presented in Task 1 is not essential to perform Task 3. However, all of the data in Task 1 is useful and much of the "homework" in preparation for performing Task 3 was done in Task 1. The Task 1 data on flight preparation tasks provided a good starting point for developing the Activities, Tasks and Subtasks essential in Task 3 for estimating and analyzing Composite Joint Resources for flight preparations.

3.1.2 Special Task 3 Guidelines

The following guidelines apply for Task 3, specifically:

a. The activity period addressed in Task 3 is limited to the pre-launch period from two years before launch through committment for launch, just prior to lift-off.

b. Only those activities that involve joint participation of STS and Payload organizational elements are addressed.

c. The Payload Operations Centers as officially recognized by NASA are applicable. These are: JSC for Spacelab Payloads; GSFC for Automated Earth Orbit Payloads (both low earth orbit and geosynchronous); and JPL for Planetary Payloads.

d. The study addresses Operational-Era Flights only, defined as all flights after six Orbital Flight Tests (OFT's), i.e., period 1980-1991.

e. The composite resources shall be estimated based on the portion of the study traffic model from 1980-1985 only.

f. The study addresses preparations for Flight Operations (including flight planning, training and simulations), but does not address Ground Operations at the Launch and Landing Sites.

g. In estimating resources required to accomplish designated pre-flight activities, it is assumed that little if any experience transfer among Spacelab - Automated Earth Orbit - Planetary Payloads (e.g., through STS Common Interface) has taken place.

h. For purposes of resources estimating, the experience break points shall be at Flights 1, 2 and 5. An assumed "loss of experience" factor due to personnel turnover is not included in estimating experience factors.

i. An "assembly-line" approach will be followed when appropriate, whereby interactive activities accomplished interactively on each flight will be repeated with the same people flight-to-flight and payload-to-payload.

j. Personnel included in the activity man-loading estimates of Task 3 are professional personnel only from all necessary organizations/functions involved in the joint tasks. This does not imply that the study team would not suggest use of "technician level" personnel where appropriate to perform the activities considered. All estimates are rounded to the nearest integer.

k. Crew functions in space will be addressed to the extent necessary to define requirements for joint preflight planning and related simulation and training functions.

3.1.3 Application of Payload Traffic Model

The STS Payload Traffic Model, Figure 3.1-1, combines the payload flight types selected for this study (including Spacelab, Automated Earth Orbit and Planetary) into a traffic model spread from 1980 through 1991. This traffic model was provided by the NASA COR on 30 April 1976 for use on the Continuation Study. The traffic rates approved for this study represent a reduced version (371 flights) of the 572-flight model approved for STS Operations Planning.

The portion of the traffic model from 1980-1985 provides the basis for estimating composite resources required in preflight planning of flight operations, training and simulations. A later table will show how the flights within each year have been scheduled so as to provide the proper time phasing of the resources for preflight preparations and to allow for summing these resources by month and year for each payload category as well as composite estimates for joint activities of all flights through 1985.

In Figure 3.1-1, the SUBTOTAL, 7-DAY FLIGHTS, actually includes all Spacelab 7-Day Flights plus the attached phase of AEO and Planetary Flights which will also be of short duration, not exceeding 7 days.

3.2 APPROACH TO TASK 3

Figure 3.2-1 is a Task 3 activity flow which provides an overall view of the technical approach to Task 3. The activity flow begins with identification of all joint activities required to insure that preflight preparations for all classes of payloads were properly integrated with the flight planning for the STS elements such that planning, training, and simulations

Group	ID	Flight Type - Payload Description	Lead PL Center	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL
SPACELAB	A	M+P, DC - ATL	LaRC	-	1	1	1	2	3	3	4	4	4	5	5	33
SPACELAB	A′	M+P, DC - OP	GSFC	-	1	1	1	2	2	2	2	2	2	2	2	19
SPACELAB	B	M+P, MD - AMPS, SP	GSFC	-	1	1	2	2	2	2	2	2	2	2	2	20
SPACELAB	B′	M+P, MD - OTHER	GSFC	1	-	-	-	1	1	2	3	3	4	5	6	26
SPACELAB	C	P ONLY, DC - SO	GSFC	-	-	1	1	2	3	5	6	6	5	6	6	41
SPACELAB	C′	P ONLY, DC - STELLAR	GSFC	-	-	-	1	1	1	1	1	1	1	1	1	9
SPACELAB	D	P ONLY, MD - HEA, SEOPS, SO	MSFC	1	1	1	2	3	4	4	4	4	4	4	5	37
SPACELAB	J_1	M ONLY, DD - LS	JSC	-	-	1	1	1	1	1	1	1	1	1	1	10
AUTO EARTH ORBIT	J_2	DELIVERY, MC - EXP, STP (DOD)	GSFC	-	1	1	1	1	1	1	1	1	1	1	1	11
AUTO EARTH ORBIT	E	DELIVER - EOS	GSFC	-	1	1	1	-	1	1	1	-	1	-	1	8
AUTO EARTH ORBIT	F	DELIVER - ST, RETRIEVE HEAO-C	MSFC	-	-	-	2	2	3	4	3	3	3	4	3	27
AUTO EARTH ORBIT	G	REVISIT W/O EVA - EOS	GSFC	-	-	-	-	1	1	-	-	1	-	1	-	4
AUTO EARTH ORBIT	H	REVISIT W/EVA - ST	MSFC	-	-	-	1	1	-	1	1	1	1	-	1	7
AUTO EARTH ORBIT	I	DELIVER MC - BESS, SEOPS, 2 MINI-LAGEOS, FFTO	ARC	-	-	-	1	1	2	2	2	2	2	1	1	14
AUTO EARTH ORBIT	K	MS, IUS - DW, COMSAT	GSFC	-	1	2	3	1	-	-	-	-	-	-	-	7
AUTO EARTH ORBIT	M	MS, TUG - TM, INTEL/SAT	GSFC	-	-	-	-	3	5	7	7	10	12	13	11	68
PLANETARY	L	MARINER	JPL	-	1	2	2	2	-	-	-	-	-	-	-	7
PLANETARY	N	PIONEER	JPL	-	-	-	-	-	4	5	6	2	3	1	2	23
		SUBTOTAL, 7-DAY FLIGHTS		2	8	11	19	25	32	38	41	39	41	42	43	341
		SUBTOTAL, 30-DAY FLIGHTS (INCLUDES J_1)		-	-	1	1	1	2	3	3	4	5	5	5	30
		TOTALS		2	8	12	20	26	34	41	44	43	46	47	48	371

LEGEND

AMPS - Atmospheric, Magnetospheric, Plasmas-in-Space
ATL - Advanced Technology Laboratory
BESS - Biomedical Experiments Scientific Satellite
DC - Dedicated Center
DD - Dedicated Discipline
DW - Disaster Warning
EOS - Earth Observation Satellite
EVA - Extravehicular Activity
EXP - Explorer
FFTO - Freeflyer Teleoperator
HEA - High Energy Astrophysics
HEAO - High Energy Astrophysics Observatory
IUS - Interim Upper Stage
LAGEOS - Laser Geodynamic Satellite
LS - Life Science
M - Module
MC - Multi-Cargo
MD - Multi-Discipline
OP - Earth and Ocean Physics
P - Pallet
PL - Payload
SEOPS - Standard Earth Observations Package for Shuttle
SO - Solar Physics
SP - Space Processing
ST - Space Telescope
STP - Space Test Program (DOD Payloads)
TM - Traffic Management

Figure 3.1-1. STS Payload Traffic Model

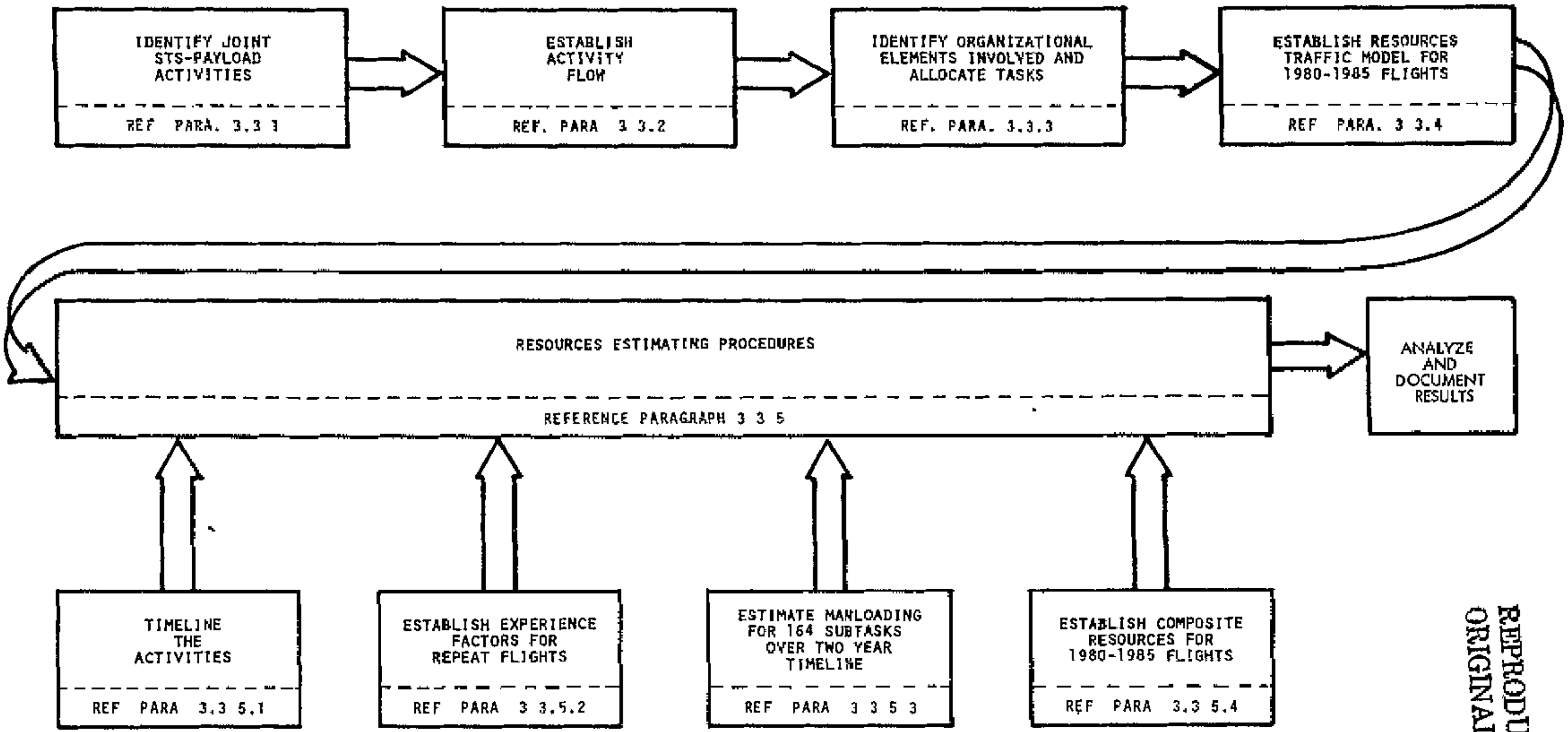

Figure 3.2-1. Task 3 Activity Flow

reflect the requirements and constraints of the total mission and its related hardware, software, personnel and support resources.

This effort resulted in identification of five prime activities, 25 tasks associated with the five activities and 164 subtasks in support of the 25 tasks. Only by breaking down the activities to these levels was it possible to realistically assess the resources required for the joint activities. A detailed discussion of this effort follows in Section 3.3.1.

The second step in the approach to Task 3 orients the activities on a general timeline covering the two year period of joint flight preparations. There are no discrete start and stop times shown for the individual activities in the activity flow diagram since this will vary somewhat depending upon flight types, level of mission complexity, experience factors, etc. Figure 3.3-1, in Section 3.3.2, shows only a general time relationship between the activities while the resources curves in Section 3.3.5 show more precise time phasing for all of the activities by flight type and experience factors.

The third block in the Activity Flow, Figure 3.2-1, alludes to the efforts to identify organizational elements involved in joint preflight preparations and allocation of the 25 tasks to one or more of the elements. This effort is described in Section 3.3.3. It basically identifies the organizations and functions involved such as the program offices, the various organizations within the Payload Operations Centers, the MCC-H, Network Operations and others. It also suggests the function for assignment of primary responsibility as well as indicating functions involved with furnishing major inputs, supportive efforts and review of the efforts for impact on their areas of responsibility.

The next activity listed in the flow diagram of Figure 3.2-1 establishes the traffic model for use in estimating resources for preflight preparations. Activities will begin two years prior to the first operational flight in 1980 and extend through launch of the flights scheduled during 1985 in this resources assessment task. Section 3.3.4 discusses the model in more detail.

The Resources Estimating Procedures which are discussed in Section 3.3.5 involve the following four efforts:

a. Timelining the Activities. In this effort an assessment was made as to when each preflight preparation planning activity and task should start and end and where throughout the two year span for joint activities, the major emphasis should occur on each task or subtask.

b. Establish Experience Factors. The break point for utilization of experience factors in estimating resources requirements has been established at Flights 1, 2 and 5. The rationale for selection of these points is discussed in Paragraph 3.3.5.2.

c. Estimation of Man-Loading. Following the establishment of timelines and experience factor criteria, the next step was to estimate the man-loading per month over the two year cycle for flight planning, training and simulations activities. In performing this effort, 60 separate manpower curves were developed. The 60 cases were based on four Payload Flight categories, five prime activities and three experience factors for each flight category and activity.

d. Establishment of Composite Resources. The final step was to establish composite resources by month and year for all five activities and four Payload Flight categories through 1985. In order to do this it was necessary to lay out the appropriate one of the 60 manpower curves against each of the 102 flight launch dates which extended from mid 1980 through 1985. It was then possible to sum the overlay of manmonths in any given column and determine the total resources as a function of time. In addition, a summary of resources by flight category and by activity has been provided in Section 3.3.5.

   Following this activity, the only remaining task in the activity flow was to analyze and document the results.

3.3 STUDY RESULTS

3.3.1 Development of Joint Activities

A major effort in Study Task 3 was to identify and define the activities associated with joint flight planning, training and simulations. To accomplish this task it was first necessary to consider all areas of involvement in flight planning and preparations and then determine what aspects of these various areas require the combined efforts of Payload Operator and STS Operator organizations or personnel to develop a coordinated planning, training or simulation activity and/or product.

It was quickly recognized that almost all STS flight preparations activities have some aspect of mutual involvement at some point prior to commencement of real-time flight operations.

Table 3.3-1 lists the five major categories of activities and the 25 principal tasks in support of these activities.

Tables 3.3-2 through 3.3-6 list 164 subtasks associated with the 25 principal tasks.

The activities, tasks and subtasks listed in the tables cover the full range of Payload types and Flight/Payload Categories. However, the tasks will apply to the various flights as applicable and in varying degrees depending upon mission complexity, whether EVA or servicing is involved and whether the IUS, SSUS or TUG is utilized. The extent of the task activities from flight to flight will be heavily influenced by the number of separate experiments which make up the cargo, the complexity of the mission and the flight duration.

These activities, tasks and subtasks as shown in the tables are the result of several iterations and considerable detailed analysis of what work must be done in preparation for flight operations and how it can best be grouped and described. The results documented here are derived from some researching of documentation as well as the experience of the study team working in support of NASA on planning and operations of manned space flights for the past 15 years. Many of the tasks and activities were documented first in Task 1 of this Study Phase (A-1) and have been expanded and supplemented based on further analysis for Task 3 and inputs from the NASA Study Evaluation Team at the Mid-Term Progress Review.

3.3.2 Activity Flow for Joint Flight Preparation

The general flow of Joint STS-Payload activities and tasks in preparation for flight may be depicted as shown on Figure 3.3-1. The Joint Program/Project Engineering Function is the initial "kickoff" activity with development of the Joint Project Plan -- task assignments, schedules, and development of Joint Flight Requirements and Flight Operations Data Base that constitute key inputs to the other activities shown. The next activities to be initiated in sequence are:

TABLE 3.3-1. MAJOR CATEGORIES/TASKS

ACTIVITY	TASKS
1. JOINT PROGRAM/PROJECT ENGINEERING FUNCTIONS	• Joint Project Planning • Joint Flight Requirements Development • STS-Payload Flight Operational Data Base • STS-Payload Flight Configuration Identification and Control • Integrated Flight Safety Evaluation and Monitoring
2. SYSTEM SUPPORT	• Communications and Data Handling • Integrated Range Requirements • Integrated Network Requirements • Joint Data Processing • Flight Software Evaluation and Modification • Ground Software Evaluation and Modification • Crew Systems Evaluation and Augmentation
3. INTEGRATED FLIGHT PLANNING	• Trajectory Analysis and Design • Attitude Timelining • Integrated Crew Activity Planning • Integrated Consumables Analysis • Subsystem Performance Analysis • Integrated Contingency Planning
4. JOINT OPERATIONS PLANNING AND PROCEDURES DEVELOPMENT	• Flight Techniques Development • Integrated Command Planning and Procedures Development • Integrated Flight Rules Development • Onboard/FCR/POCC Procedures, Checklists, Reference Data Development
5. TRAINING AND SIMULATIONS	• Joint/Integrated Training and Simulations Requirements Development • Joint/Integrated Training and Simulations Planning • Conduct Joint/Integrated Training and Simulations

TABLE 3.3-2. JOINT PROGRAM/PROJECT ENGINEERING TASKS/SUBTASKS

TASK	SUBTASK
• JOINT PROJECT PLANNING	- Identify Joint Tasks and Products - Establish Joint Organizational Structure - Allocate Tasks and Establish Authorized Contacts - Develop Task/Deliverable Sequences/Schedules/Milestones - Establish Groundrules/Guidelines/Special Procedures - Analyze Task Activity Schedules/Develop Recommended Adjustments - Identify Joint Working Group/Panel Recommendations and Establish Purpose, Functions, Organization, Membership - Prepare, Coordinate, Obtain Approvals on Joint Project Plan (document)
• JOINT FLIGHT REQUIREMENTS DEVELOPMENT*	- Establish STS Capability to Accomplish Payload Flight Requirements • Orbits • Pointing Targets Accuracy • Constraints - Establish Joint Data Requirement - Identify Payload Monitoring by STS - Identify Payload Handling by STS - Identify Augmentation of Payload Crew by STS Crewman - Establish Special STS Accommodations - Establish Hitchhiker Capacity and Selections - Establish Flight Objective Priorities and Alternative Flight Guide-lines - Prepare, Coordinate, Obtain Approvals on Joint Flight Requirements Document
• STS-PAYLOAD FLIGHT OPERATIONAL DATA BASE	- Identify Joint Usage Subsystems Operational Data - Establish Subsystems Nominals and Limit Criteria - Establish Joint Mass Properties Data - Develop Joint Consumables Data and Establish Redlines - Identify and Document Pertinent Subsystem Test Data - Establish Joint Equipment Stowage Criteria - Develop and Configure Joint Data Base - Prepare Required Documentation/Data Base Inputs, and Obtain Appro-priate Coordination/Approvals - Establish Data Base Change Control Procedure

*NOTE: Assume Identification of Flight/Mission Objectives is Uniquely a Payload Function.

TABLE 3.3-2. JOINT PROGRAM/PROJECT ENGINEERING TASKS/SUBTASKS (CONTINUED)

TASK	SUBTASK
• STS-PAYLOAD FLIGHT CONFIGURATION IDENTIFICATION AND CONTROL	- Identify and Document Joint STS-Payload Flight Configuration from Liftoff through Landing, including Contingency Cases - Establish Techniques for In-flight Manipulation of Payload Items by STS Elements (RMS, EVA Crew) - Evaluate Flight Plan for Major Shifts in Joint Flight Configuration and Assess Potential Impact - Generate Listings and Timelines of Joint Stow/Unstow Items - Establish Guidelines for Transfer of STS-Payload Equipment/Cargo/Personnel during Flight - Maintain Current Flight Configuration Record during Preflight Buildup and during Flight Operation - Prepare, Coordinate and Obtain Approvals on Joint Flight Configuration Documentation
• INTEGRATED FLIGHT SAFETY EVALUATION AND MONITORING	- Identify Potential Flight Hazards, Label Those to be Evaluated - Evaluate Hazards, Establish Recommendations/Rationale - Evaluate Adequacy of Caution and Warning (C&W) Parameters and Methodology, Establish Caution and Warning Techniques - Establish Onboard Safety Procedures - Determine Adequacy of Planned Abort/Contingency Procedure and Augment where Necessary - Conduct Flight Safety Reviews - Conduct Flight Readiness Review - Prepare, Coordinate, Obtain Approvals on Joint Flight Safety Documentation - Prepare Documentation on Hazard Evaluations - Prepare Flight Rules Inputs

TABLE 3.3-3. SYSTEM SUPPORT TASKS/SUBTASKS

TASK	SUBTASK
• COMMUNICATIONS AND DATA HANDLING	- Establish Joint Requirements for Uplinks/Downlinks/Groundlinks, Including TM Data, Video, Voice-Sources, Destinations, Modes, Loads and Schedules for All Links - Establish Data Handling Plans for Payload Data Transmitted via STS Links - Establish Data Formats for Display and Evaluations of Joint Data Interests - Real-Time, Near-Real-Time and Postflight - Prepare, Coordinate and Obtain Approval of Joint Communications and Data Handling Plan
• INTEGRATED RANGE REQUIREMENTS	- Identify and Document on Preformatted Pages (Program Requirements Document) Joint Launch and Landing Range Requirements, e.g., Tracking, Propellants and Gases, Checkout Facilities, ----- - Review Range Regulations for Joint STS Payload Compliance, List the Data Required - Coordinate and Obtain Approvals on Joint STS-Payload Data Submitted for Range Compliance - Develop and Document Data Required for Joint Compliance with Range Safety Requirements such as Range Safety "Debris Data" and Destruct System Design Data - Review Range Responses and Negotiate any Differences Between Program/Project and Range
• INTEGRATED NETWORK REQUIREMENTS	- Identify and Document on Preformatted Pages (Support Instrumentation Requirements Document) Joint Requirements on the Network (Joint Flight Phases), such as Telemetry Data, Voice, Video Transmissions - Review Network Responses and Negotiate any Differences Between Program/Project and Network - Provide Inputs to Network for Joint STS-Payload Tests with the Network - Coordinate and Obtain Approvals on Joint STS-Payload Data Submitted to the Network - Review Network Responses and Negotiate any Differences Between Program/Project and Range

TABLE 3.3-3. SYSTEM SUPPORT TASKS/SUBTASKS (CONTINUED)

TASK	SUBTASK
• JOINT DATA PROCESSING	- Identify and Document Joint Data Processing Requirements for Real-Time and Near-Real-Time Applications - Establish and Document Plans for Real-Time and Near-Real-Time Joint Data Processing - Identify and Document Joint Data Processing Requirements for Postflight Evaluation - Establish Joint Postflight Data Processing and Evaluation Plans - Establish Computer Requirements, Implementation Approach and Resources - Coordinate and Obtain Approvals on Joint Data Processing Documentation
• FLIGHT SOFTWARE EVALUATION AND MONITORING	- Evaluate and Establish Joint Requirements for Flight Software - Identify Applicable Standard Software Modules - Evaluate and Establish Flight Software Changes Required - Establish Joint Software Verification Requirements and Plans - Establish Joint Software Configuration Control Procedures and Process Changes - Prepare, Coordinate and Obtain Approvals on Joint Software Documentation - Identify, Document and Validate Computer Constants/Loads Needed for Joint Operations
• GROUND SOFTWARE EVALUATION AND MONITORING	- Evaluate and Establish Joint Requirements for Ground Software - Identify Applicable Standard Software Modules - Evaluate and Establish Ground Software Changes Required - Establish Joint Software Configuration Control Procedure and Process Changes - Establish Joint Software Verification Requirements and Plans - Prepare, Coordinate and Obtain Approvals on Joint Software Documentation - Identify, Document and Validate Computer Constants/Loads Needed for Joint Operations

TABLE 3.3-3. SYSTEM SUPPORT TASKS/SUBTASKS (CONTINUED)

TASK	SUBTASK
• CREW SYSTEMS EVALUATION AND AUGMENTATION	- Evaluate Integrated Crew Activity Plan and Assess Impact on Crew Systems - Identify Crew System Augmentation Requirements - New/Modified Capabilities - Prepare and Process New Specifications/Changes to Existing Specifications - Develop and Test New/Modified Crew Systems Capabilities

TABLE 3.3-4. INTEGRATED FLIGHT PLANNING TASKS/SUBTASKS

TASK	SUBTASK
• TRAJECTORY ANALYSIS AND DESIGN	- Establish Trajectory Design Requirements and Constraints - Identify Applicable Standard Trajectory Modules Previously Developed - Establish Launch/Injection Windows - Establish and Timeline Major Trajectory Events, Maneuvers, Beta Angles, Day-Night Cycles, --- - Design the Trajectory and Simulate on Computer - Develop Rendezvous and Separation Options as Required - Evaluate Trajectory Events Against Periods Without Communications and Rectify - Develop Data Packages for Use in Joint Simulations and Flight Software-Ground Software Input - Establish Guidance and Navigation Dispersions/Accuracies - Prepare, Coordinate and Obtain Approvals on Joint Trajectory Design and Analysis Documentation
• ATTITUDE TIMELINING	- Establish Attitude References for the Flight Orbit - Establish Pointing Target Requirements - Establish Attitude Rates and Accuracy Requirements - Develop Preliminary Attitude Timeline - Establish Attitude Constraint Conditions - Thermal, Contamination, Communications, ----- - Analyze Attitude Requirements versus Constraints to Establish Acceptable Joint Attitude Timeline - Prepare, Coordinate and Obtain Approvals on Joint Attitude, Timeline Documentation
• INTEGRATED CREW ACTIVITY PLANNING	- Evaluate Trajectory and Flight Requirements for Crew Activity Periods - Establish Crew Work-Rest Cycle, Number of Crewmen per Activity and Crew Assignments - Analyze Crew Skill Requirements and Recommend Type of Training Required - Analyze Timeline for Onboard Data Requirements, i.e., Procedures, Checklists, Reference Data (Decals, Charts, etc.) and Additional Software - Develop Alternate Timeline Options - Prepare, Coordinate and Obtain Approval on Integrated Crew Activity Timelines (Summary/Detailed)

TABLE 3.3-4. INTEGRATED FLIGHT PLANNING TASKS/SUBTASKS (CONTINUED)

TASK	SUBTASK
• INTEGRATED CONSUMABLES ANALYSES	- Assess Applicable Consumables Usage on Similar Prior Flights and Update Data Base - Analyze Timelines to Establish Consumables Requirements and Time Histories - Establish Flight Loading Requirements and Redlines for Launch and On-orbit - Develop Flight Consumables Data Files
• SUBSYSTEM PERFORMANCE ANALYSES	- Analyze Integrated Flight Trajectory and Crew Activity Plans, Verify Avionics Performance Capability - Analyze Integrated Flight Trajectory and Crew Activity Plans, Verify Thermal/ECS Performance Capability - Analyze Integrated Flight Trajectory and Crew Activity Plans, Verify Communications and Data System Performance Capabilities - Analyze Integrated Flight Trajectory and Crew Activity Plans, Verify Structures and Mechanical Systems Performance Capabilities - Analyze Integrated Flight Trajectory and Crew Activity Plans, Verify Power and Propulsion Performance Capabilities - Prepare Documentation to Certify Flight Readiness, All Subsystems
• INTEGRATED CONTINGENCY PLANNING	- Establish Abort Mode Boundaries - Develop Crew Charts and Flight Controller Charts - Establish Entry Target Line for Abort-to-Once Around - Develop Targeting and Guidance Values - Evaluate Mass Properties Conditions for Potential Aborts and Determine Reconfiguring/Off-Loading Requirements - Prepare, Coordinate and Obtain Approvals on Joint Abort Trajectory Design and Analysis Documentation

TABLE 3.3-5. JOINT OPERATIONS PLANNING AND PROCEDURES DEVELOPMENT TASKS/SUBTASKS

TASK	SUBTASK
• FLIGHT TECHNIQUES DEVELOPMENT	- Analyze Major Flight Events and Identify Standard versus Flight-unique Techniques - Develop Differences from Joint Operations Logic Charts where Required by Payload Operations - Analyze Amended Logic Charts for Impact on Joint Operations - Prepare, Coordinate, Obtain Approvals on Joint Flight Techniques Documentation
• INTEGRATED COMMAND PLANNING AND PROCEDURES DEVELOPMENT	- Analyze Flight Activities to Identify Integrated Command Requirements - Develop and Format the Integrated Commands Compatible with STS Capabilities - Develop Additional (Non-Standard) Command Procedures as Required - Develop and Perform Command Validation and Verification Procedures - Establish Integrated Command Plan (Sequence) - Develop Command Backup Plan and Procedures - Establish Plan and Procedures for Building Real-Time Command History - Prepare, Coordinate and Obtain Approvals on Integrated Command Planning and Procedures Documentation

TABLE 3.3-5. JOINT OPERATIONS PLANNING AND PROCEDURES DEVELOPMENT TASKS/SUBTASKS (CONTINUED)

TASK	SUBTASK
• INTEGRATED FLIGHT RULES DEVELOPMENT	- Analyze Payload Operations Criteria for Impact on Standard Flight Rules - Develop Rationale for Integrated Flight Rules - Develop Integrated Flight Rules for Each Flight Phase - Establish Actions to Avoid Rules Violation/Take Corrective Action when Rules Violated - Prepare, Coordinate and Obtain Approval on Integrated Flight Rules Document
• ONBOARD/FCR/POCC PROCEDURES/ CHECKLISTS AND REFERENCE DATA DEVELOPMENT	- Identify Standard Modules and Evaluate Integrated Crew Activity Plan for Additional Requirements - Generate/Update Procedures/Checklists and Reference Data - Validate and Verify Compatibility of New/Modified Procedures/ Checklists/Reference Data - Prepare, Coordinate and Obtain Approvals on New/Modified Procedures/ Checklists/Reference Data - Process Changes Required to Existing Procedures/Checklists/Reference Data - Produce Additional Flight-Qualified Onboard Data Required

TABLE 3.3-6. TRAINING AND SIMULATIONS TASKS/SUBTASKS

TASK	SUBTASK
● JOINT AND INTEGRATED TRAINING AND SIMULATIONS REQUIREMENTS DEVELOPMENT	- Determine Training and Simulations Objectives • STS Crew Training/Simulations for Payload Operation • Payload Crew Training/Simulations for STS Operations • Integrated Crew Training/Simulations for Flight Operations - Evaluate Crew Experience/Skill Levels - Analyze Flight Activities and Experience/Skill Factors for Training/Simulation Task Requirements - Establish Requirements for Training/Simulations Data/Hardware/Software - Establish Requirements for Instructor Personnel - Establish Facility Usage and Training/Simulation Support Requirements - Establish Training and Simulations Sequencing and Scheduling Criteria - Develop Training and Simulations Evaluation and Certification Criteria - Prepare, Coordinate and Obtain Approvals on Joint and Integrated Training/Simulations Requirements Documentation
● JOINT AND INTEGRATED TRAINING AND SIMULATIONS PLANNING	- Assign Training and Simulation Tasks - Develop Training and Simulation Sequences and Schedules - Develop Evaluation and Certification Procedures - Prepare, Coordinate and Obtain Approvals on Joint/Integrated Training and Simulations Plan
● CONDUCT JOINT/INTEGRATED TRAINING AND SIMULATIONS	- Perform Joint/Integrated Classroom Training - Perform Payload Crew Training on STS Operations - Perform STS Crew Training on Payload Operations - Perform Integrated Crew Training - Perform EVA Training - Perform Integrated Simulations - Validate and Verify Flight Data - Certify Crew Performance, Flight and Ground Crews

- Integrated Flight Planning -- trajectory design, timelines, consumables analyses, subsystems performance analyses.
- System Support -- communications and data handling/processing, range and network requirements, software and crew systems analyses.

The last activities to be completed, since they depend heavily on input from trajectory design, crew activity timeline and systems analyses which are completed earlier are:

- Joint Operations Planning and Procedures Development -- integrated command planning, flight rules and flight techniques development, onboard/FCR/POCC procedures and supporting data.
- Training and Simulations -- to ready the Joint/Integrated Crews for the flight and verify timelines and procedures.

As indicated by the dashed arrows in Figure 3.3-1 , the Joint Operations Planning and Procedures Development is an iterative activity with Training and Simulations.

While all of the activities involve planning and preparation for the real-time operation, the training and simulation activity involves the performance of training and simulations as well as the planning, scheduling and preparations for same.

3.3.3 Involvement of Operational Elements in Preparation for Flight Operations

Figure 3.3-2 shows the involvement of operational elements as associated with the 25 flight preparation tasks. "P" designates the functions recommended for primary responsibility. "I" indicates those functions which provide inputs, major reviews, support and/or committments of resources.

The first three columns indicate functions performed by the program offices, i.e., Shuttle Payload Integration and Development Program Office, (SPIDPO), STS Program Office, and Payload Program Offices, respectively. SPIDPO logically would be responsible for the majority of program office activities which involve interfaces between the STS and Payloads, with notable exception of the flight requirements specified by the Payload Program Offices.

The next grouping concerns the functions which normally take place within a Payload Operations Center (POC). Under this column grouping, (the POC's which include JSC, GSFC, and JPL), the supporting functions involve Payload Operations Control Centers (POCC's), Payload Coordinators

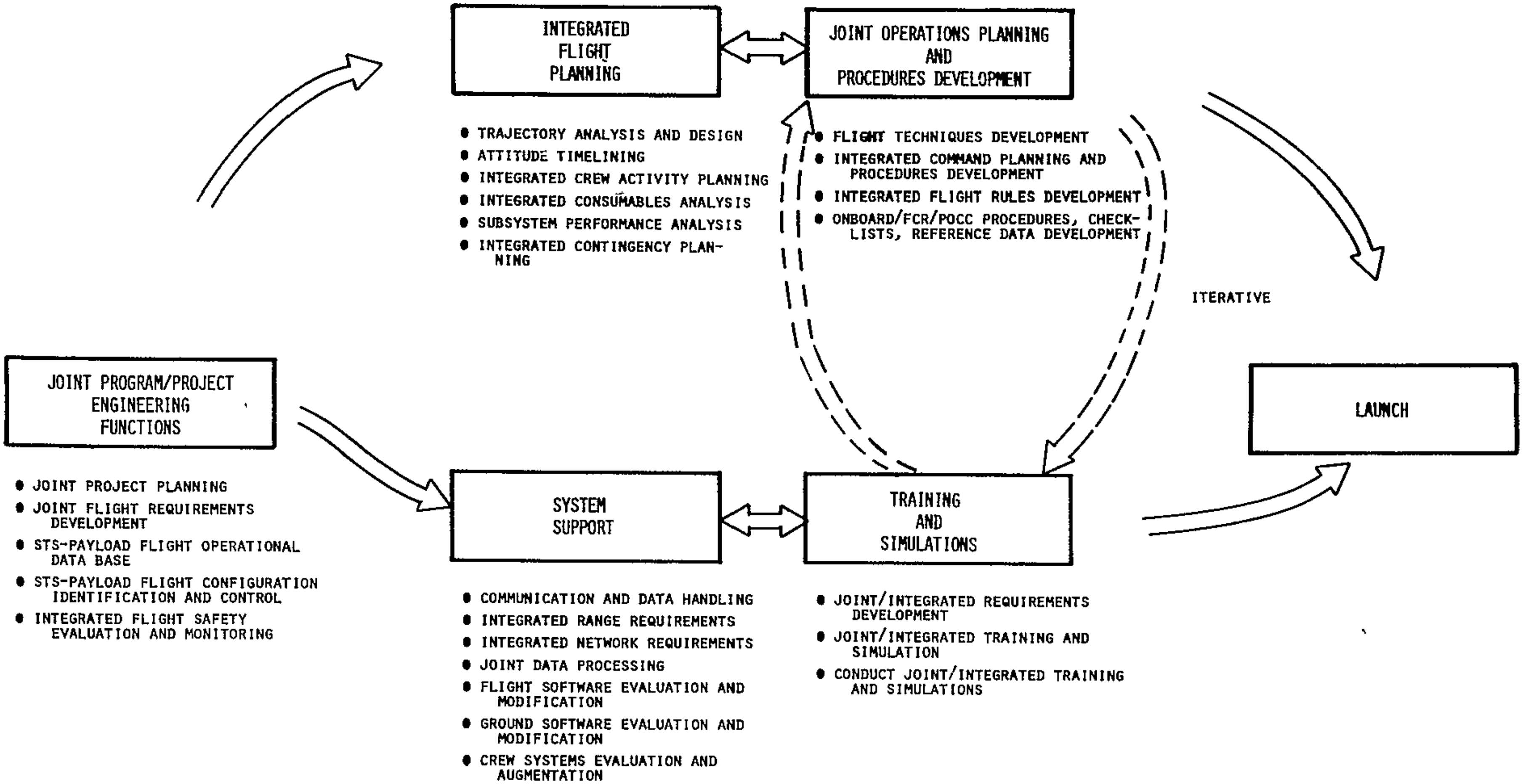

Figure 3.3-1. Activity Flow for Joint STS-Payload Flight Preparation

JOINT ACTIVITY / STS/PAYLOAD OPERATIONAL FUNCTIONS	SPIDPO	STS PROJECT OFFICE	PAYLOAD PROJECT OFFICE (INDIVIDUAL OR INTEGRATED)	POC: POCC	POC: PAYLOAD COORDINATOR (PC)	POC: FLIGHT DESIGN GROUP	POC: CREW ACTIVITY PLANNING	POC: TRAINING AND SIMULATIONS	POC: COMMUNICATIONS AND DATA HANDLING	POC: DATA PROCESSING	MCC-H (STS OPERATOR)	INTEGRATED OPERATIONS MANAGER (IOM)	NETWORK OPERATIONS	LAUNCH/LANDING SITE INTERFACES	STS FLIGHT CREW	PAYLOAD FLIGHT CREW	MISSION MANAGER
• JOINT PROJECT PLANNING	P	I	I	I	I	I	I	I	I	I	I	I	I	I			I
• JOINT FLIGHT REQUIREMENTS DEVELOPMENT	I	I	P		I						I	I					I
• STS-PAYLOAD FLIGHT OPERATIONAL DATA BASE	P	I	I														
• STS-PAYLOAD FLIGHT CONFIGURATION IDENTIFICATION AND CONTROL	P	I	I		I							I					I
• INTEGRATED FLIGHT SAFETY EVALUATION AND MONITORING	P	I	I		I						I	I			I	I	I
• COMMUNICATIONS AND DATA HANDLING	I	I	I	I	I	I	I		I	I	P	I	I	I			I
• INTEGRATED RANGE REQUIREMENTS	I	I	I			I			I	I	P		I	I			
• INTEGRATED NETWORK REQUIREMENTS	I	I	I	I		I	I		I	I	P		I	I			
• JOINT DATA PROCESSING	I	I	I	I		I			I	I	P		I	I			
• FLIGHT SOFTWARE EVALUATION AND MODIFICATION	I	I	I								P				I	I	I
• GROUND SOFTWARE EVALUATION AND MODIFICATION	I	I	I	I					I	I	P		I	I			I
• CREW SYSTEMS EVALUATION AND AUGMENTATION	I	I	I				I	I			P				I	I	I
• TRAJECTORY ANALYSIS AND DESIGN	I	I	I			I	I	I	I		P		I				I
• ATTITUDE TIMELINING	I	I	I			I	I	I			P				I	I	I
• INTEGRATED CREW ACTIVITY PLANNING	I	I	I	I		I	I	I			P				I	I	I
• INTEGRATED CONSUMABLES ANALYSIS	I	I	I			I	I	I			P				I	I	I
• SUBSYSTEM PERFORMANCE ANALYSIS	P	I	I			I	I				I						
• INTEGRATED CONTINGENCY PLANNING	I	I	I		I	I	I	I	I		P	I	I		I	I	I
• FLIGHT TECHNIQUES DEVELOPMENT	I	I	I	I	I	I	I	I	I		P		I	I	I	I	I
• INTEGRATED COMMAND PLANNING AND PROCEDURES DEVELOPMENT	I	I	I	I		I	I	I	I		P		I	I	I	I	I
• INTEGRATED FLIGHT RULES DEVELOPMENT	I	I	I	I	I			I			P	I	I	I	I	I	I
• ONBOARD/FCR/POCC PROCEDURES CHECKLISTS REFERENCE DATA DEVELOPMENT				I		I	I	I	I		P				I	I	
• JOINT/INTEGRATED TRAINING AND SIMULATIONS REQUIREMENTS DEVELOPMENT	I	I	I	I		I	I	I			P				I	I	I
• JOINT/INTEGRATED TRAINING AND SIMULATIONS PLANNING	I	I	I	I		I	I	I			P				I	I	I
• CONDUCT JOINT/INTEGRATED TRAINING AND SIMULATIONS				I		I	I	I			P				I	I	

LEGEND:
P = PRIMARY RESPONSIBILITY
I = MAJOR INPUT/SUPPORT

Figure 3.3-2. Involvement of Operational Elements in Preparations for Flight Operations

FOLDOUT FRAME 1

FOLDOUT FRAME 2

(PC's), Flight Design, Crew Activity Planning, Training and Simulations, Communications and Data Handling, and Data Processing.

The MCC-H, (STS Operator) has been suggested as the responsible element for the flight and operations planning activities which comprise the majority of Joint Preflight Activities.

Other functions which support or have inputs to the activities include; Integrated Operations Manager (IOM), Network Operations, Launch/ Landing Site Interfaces, STS Flight Crew, Payload Flight Crew and Mission Manager.

Most of the listed functions are well known; however, two of the functions evolved as part of the concepts for STS Payload Operations developed in Task F of the basic Payload Mission Control Study. It may, therefore, be helpful to review the functions of the Payload Coordinator (PC) and the Integrated Operations Manager (IOM), as envisioned in the Task F Concept in order to explain the "I" notations in those two columns.

The Payload Coordinator function is envisioned as a small group at each Payload Operations Center whose responsibility is to coordinate resources and resolve conflicts between payloads of a given class such as Spacelab, Automated Earth Orbiting or Planetary Payloads so as to provide the STS Operator a single point contact for the resolution of interface problems among payloads within a class or Center. This would preclude the STS Operator from having to coordinate changes in schedules, and resolve conflicts by dealing with all the separate project offices involved in situations where several payloads of a given class are competing for Network support, or other resources especially in a contingency situation requiring real-time replanning of flight activities. The PC should, therefore, become involved in certain flight planning activities in order to be in a knowledgeable position to act when problems arise during the real-time flight operation.

The IOM is a function which integrates the activities of all Payload classes. Again this is primarily a decision making function which operates during the real-time operation. The IOM represents the payload world. It functions at a management and decision making level and

primarily is brought into play when payloads of different classes are competing for limited resources. Again, it provides a single point of contact for the STS Operator to resolve problems affecting different classes of payloads. The involvement of the IOM in preparations for flight operations is primarily an information exchange and an involvement that will prepare the IOM function to execute its role effectively during the real-time operation.

Neither the PC nor the IOM become involved in the detailed day-to-day operation, either from a flight planning or real-time operational point of view. Their activities are executed at a higher level and their functions become more critical as the flight rate of Shuttle flights increases toward the upper level of the traffic model.

The joint activities shown in the left column of Figure 3.3-2 are the same 25 activities for which manning levels have been generated in the resources estimation task.

This Figure was of considerable assistance in estimating resources since it gave an indication of the total number of separate functions or organizations involved in coordinating on a given activity and then some indication of the level of interface activity.

3.3.4 Establish Traffic Model for Resources Estimation for Flights 1980 through 1985

For the purpose of establishing man power resource estimates as a function of time, it was necessary to expand the payload traffic model by making some assumptions as to the launch dates for all flights within a given year.

Table 3.3-7, STS Payload Traffic Model Summary shows the number of each class of payload operational flights to be launched in each year from 1980 through 1985. The numbers in parenthesis indicate flights per year, the other numbers in the block indicate the months of that year in which launches are scheduled. In order to avoid having fractional manmonth estimation of resources, launches are not scheduled other than by months, i.e., where more than 12 launches occur during a given year, rather than

TABLE 3.3-7. STS PAYLOAD TRAFFIC MODEL, SUMMARY OF OPERATIONAL ERA FLIGHTS THRU 1985

YEAR / PAYLOAD CATEGORY	1980	1981	1982	1983	1984	1985	TOTAL OPERATIONAL FLIGHTS THRU 1985
Spacelab 7-Days	(2) 6,12	(4) 3,6,9,12	(5) 3,6,7,9 12	(8) 2,4,5,6 8,9,10, 12	(13) 1,2,3,4 5,6,6,7 8,9,10, 11,12	(15) 1,2,3,3 4,5,6,6 7,8,9,9 10,11,12	47
Spacelab 30-Days			(1) 6	(1) 6	(1) 6	(2) 6,12	5
Automated Earth Orbit		(3) 4,8,12	(4) 3,6,9,12	(9) 2,4,5,6 7,8,10, 11,12	(10) 1,2,3,4 6,7,8,9 11,12	(13) 1,2,3,4 5,6,6,7 8,9,10, 11,12	39
Planetary		(1) 6	(2) 6,12	(2) 6,12	(2) 6,12	(4) 3,6,9,12	11
TOTAL OPERATIONAL FLIGHTS/YEAR	2	8	12	20	26	34	102

<u>SAMPLE TABLE ENTRY INTERPRETATION</u>: " (4) 3,6,9,12" under "Spacelab 7-Days" in 1981 means there are 4 flights scheduled, in months 3,6,9,12.

center the launches equidistant throughout the year, the excess launches over 12 will be doubled up in various months throughout the year on a symmetrical schedule. This will give a reasonable approximation of resources for the case where launches are scheduled at a relatively constant launch rate throughout the year. This concept is in keeping with the necessity to regulate STS Flights for proper utilization of launch pads and other resources.

Each of the 102 flights through 1985 has been given a separate identification number for purposes of computing the resources as a function of time.

3.3.5 Resources Estimating Procedures

The procedure for estimating the manning resources for the five activities will be discussed in Paragraphs 3.3.5.1 through 3.3.5.4.

3.3.5.1 Timelining the Activities

Prior to any attempt to schedule the manpower for each task in detail, it was necessary to block out a general timeline for each of the 25 tasks and insure that the timing relationship between the blocks was in general accord with the requirements for inputs and outputs of the various tasks to interact with each other. Having determined where each task should start and end and where the major emphasis should be throughout the two year preflight planning period, it was then possible from this rough timeline to proceed to the next steps in the procedure and schedule the manpower for each task by month in estimating the time phasing of human resource requirements.

3.3.5.2 Establishing Experience Factors

It is obvious that once the joint flight preparation activities have been performed for one of each class of payloads there will be a significant improvement in the efficiency of succeeding activities of a similar nature.

On the initial iteration for each task, basic formats and procedures must be developed, personnel responsible for the various interfacing functions must learn to work together for the first time and personnel will be required to think out each task in great detail. Thus, there is a major "break point" in experience impact after Flight 1 at Flight 2.

Successive flights will differ in detail but preflight planning, training and simulations will be conducted in much the same framework as the initial flights of a given type. One major limitation to achieving substantial reductions in manpower between Flights 1 and 2 is the inability to apply all that was learned from Flight 1, toward improving the activities for Flight 2 because of insufficient time between the flights to implement necessary changes. However, it is reasonable to expect that all experience from Flight 1 can be reflected into improvements in efficiency by the time Flight 5 occurs. In addition, the experience derived from Flights 2, 3 and 4 can be used to confirm the lessons learned from the initial preflight planning efforts and help to formulate changes that will improve efficiencies. Thus, the next "break point" in experience selected is Flight 5, so that three "Experience Factors" are established to be implemented at Flights 1, 2 and 5, respectively.

After the fifth flight of each type, further improvements will be made and additional reductions in manpower expended per flight will result. However, these changes will be gradual, as they will involve improvements such as modularizing procedures and planning data, computerizing various manual tasks such as scheduling and documentation generation, and elimination of redundant activities as confidence builds up in STS Operations. Since these changes are expected to occury very gradually as the system operations mature, no discrete step reductions in manpower have been estimated beyond Flight 5 of each payload category.

3.3.5.3 Estimation of Man-Loading

The procedures followed in estimating man-loading was to analyze each task and subtask in terms of the efforts to be performed, when they should be performed, what functional organizations and skills were involved, the number of separate interfaces, documentation and/or products to be produced, and the likely availability of input material or data from sources outside the joint task performer group. This analysis was made on a task by task basis estimating the manpower for each payload category starting with the first flight and then proceeding to estimate the reduction in manpower resulting from the experience factors.

The manpower estimates for each task were summed on worksheets to form the composite manpower curves for each of 60 activity cases. These 60 cases are presented in Figure 3.3-3 through 3.3-22 and show the totals for the five activities for the four payload categories and three experience factors.

3.3.5.4 Establishment of Composite Resources

The last step in the procedure was to associate the 60 separate manpower curves with the flight dates for the 102 flights which occur in the payload traffic model from 1980 through 1985. It was then necessary to plot the overlays of manpower for all individual cases keyed to flight dates in order to sum the total manpower by month and year.

Figure 3.3-23 shows pictorially the steps involved in the final estimation of composite resources.

To facilitate computing the composite resources by month and year, a resources estimating structure was developed (Figure 3.3-24 thru 3.3-28). These diagrams assign unique code numbers to Payload Categories, Activities and Individual Flights and organize these elements into a hierarchy for use in computing the composite resources.

The results were documented in terms of total resources for each class of payload, total resources by year and month for each class of payload, and total resources by year and month for each activity from 1978 through 1985.

3.3.5.5 Computer Resources

It was deemed useful to estimate the joint computer resources for the initial preflight preparation phase of each class of payload flight.

Analysis indicates that total computer resources will amount to less than 10% of the cost of manpower resources throughout the two year flight preparation cycle. Therefore, the computer resources will not be a major driver in terms of overall costs. For this reason, the effort extended to obtain accurate estimates of computing time were far less extensive than the efforts to obtain accurate manpower estimates.

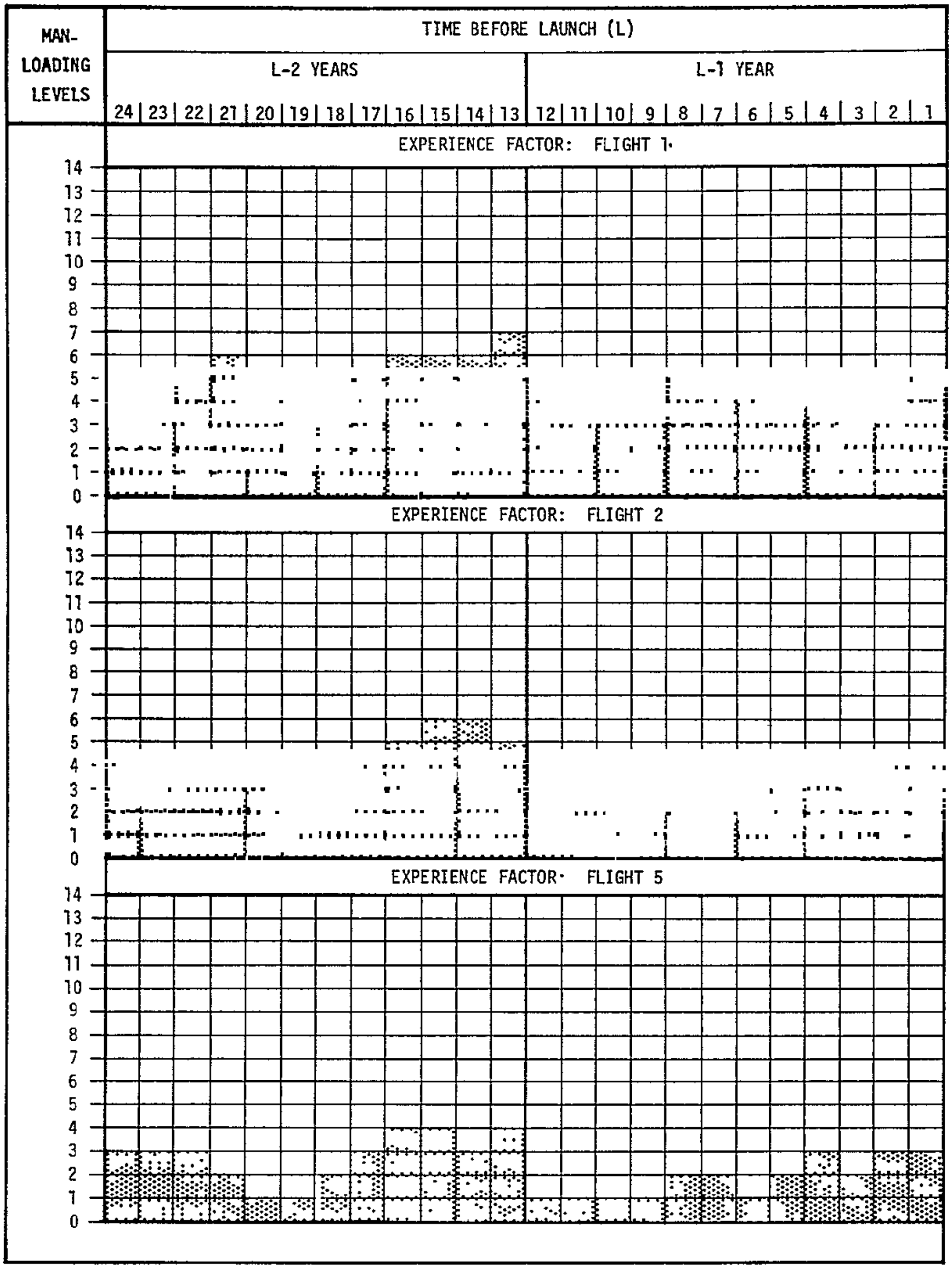

Figure 3.3-3. Spacelab Payloads 7-Day Flights,
Joint Program/Project Engineering Functions (1AA1)*

*See Figures 3.3-24 thru 3.3-28 for Code Interpretations

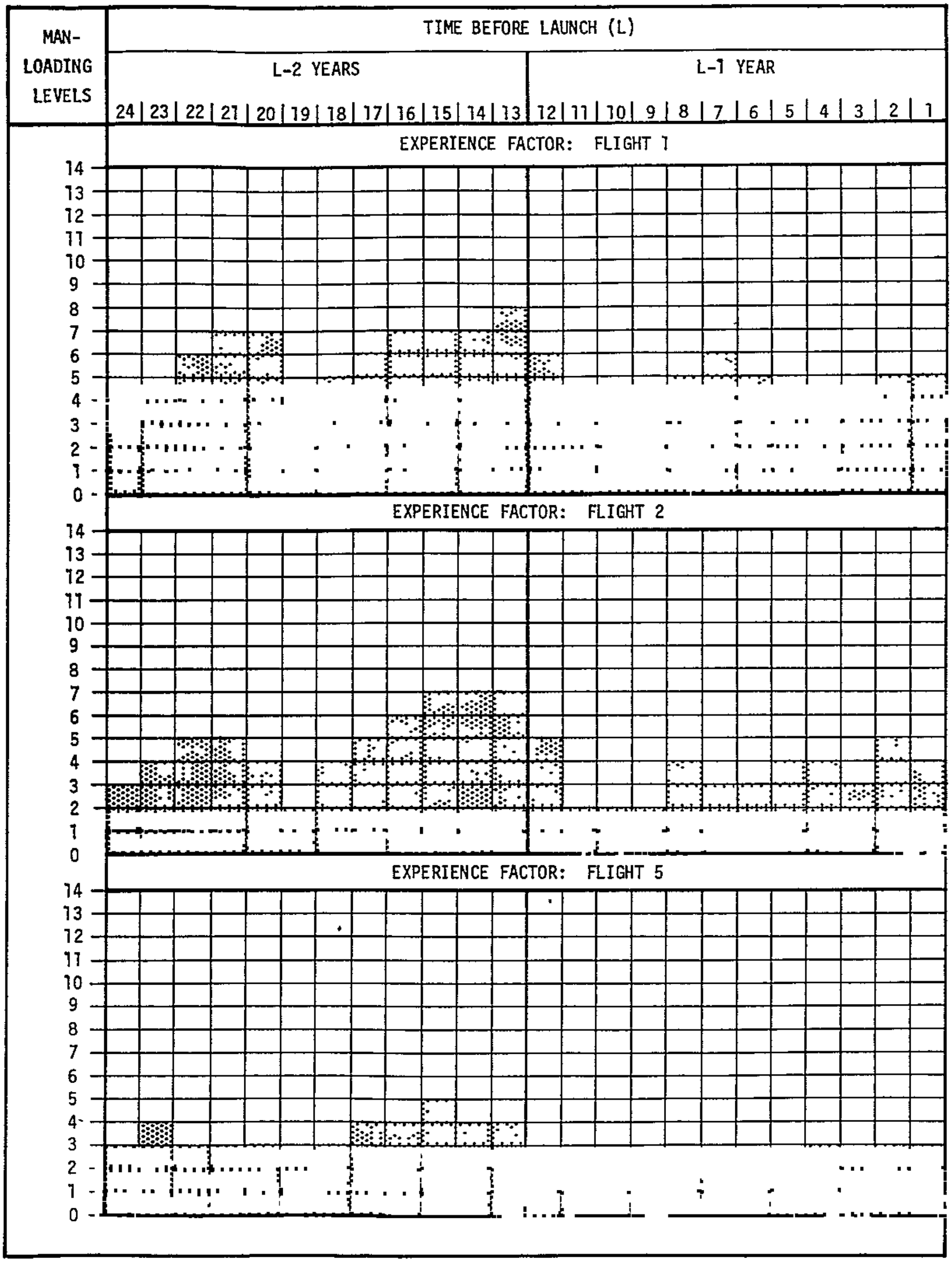

Figure 3.3-4. Spacelab Payloads 30-Day Flights,
Joint Program/Project Engineering Functions (1AB1)

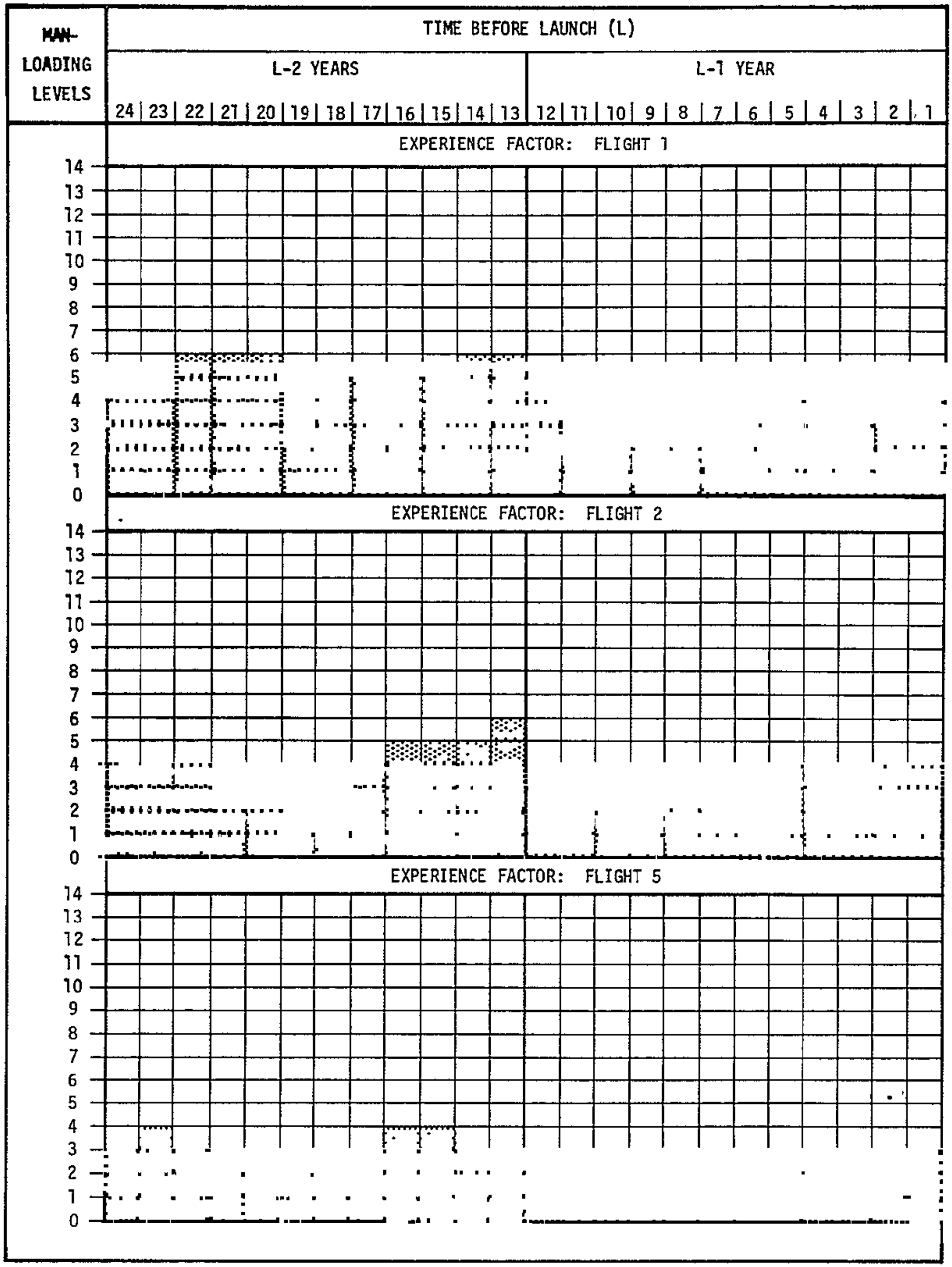

Figure 3.3-5. AEO Payloads, Joint Program/Project Engineering Functions (1B1)

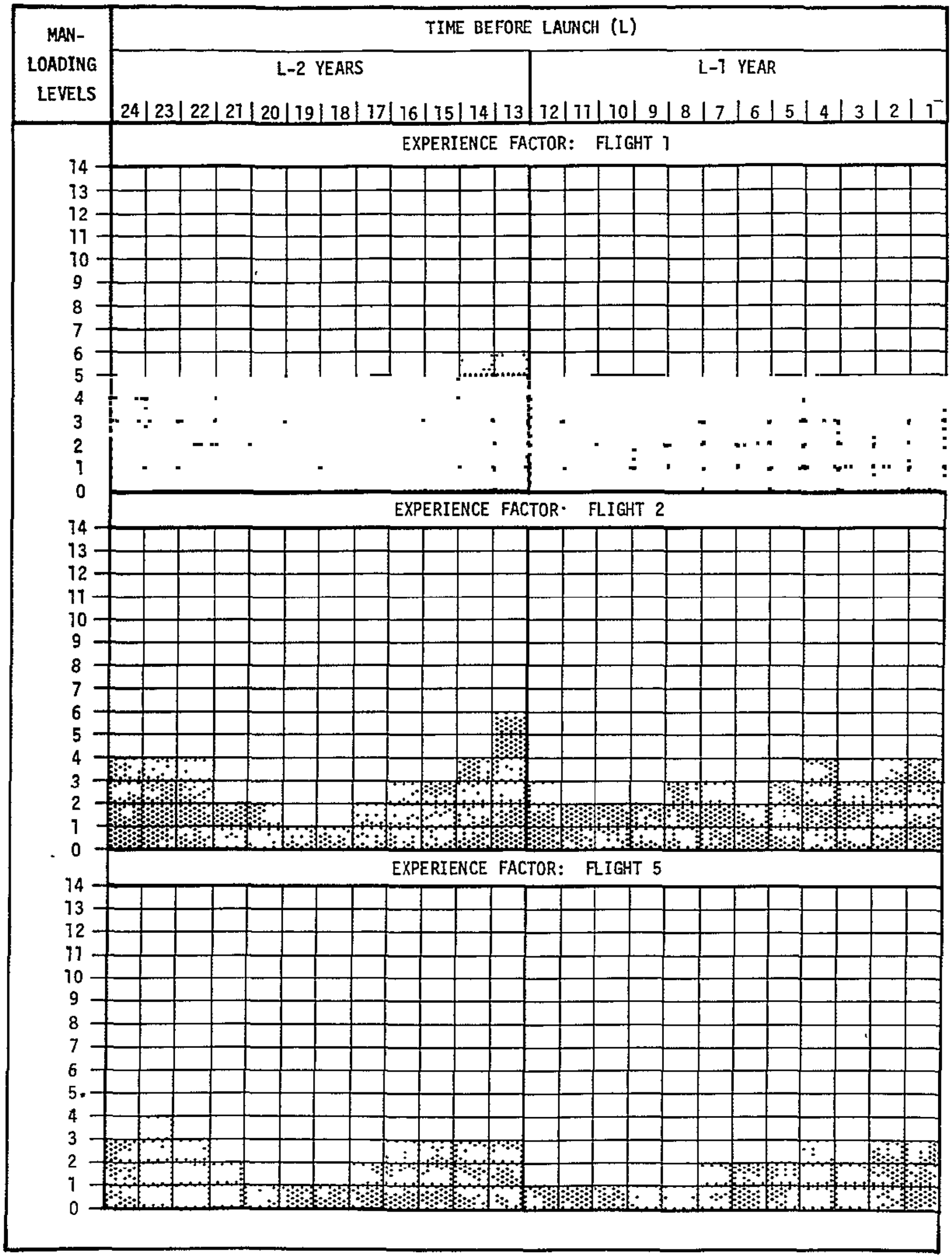

Figure 3.3-6. Planetary Payloads,
Joint Program/Project Engineering Functions (1C1)

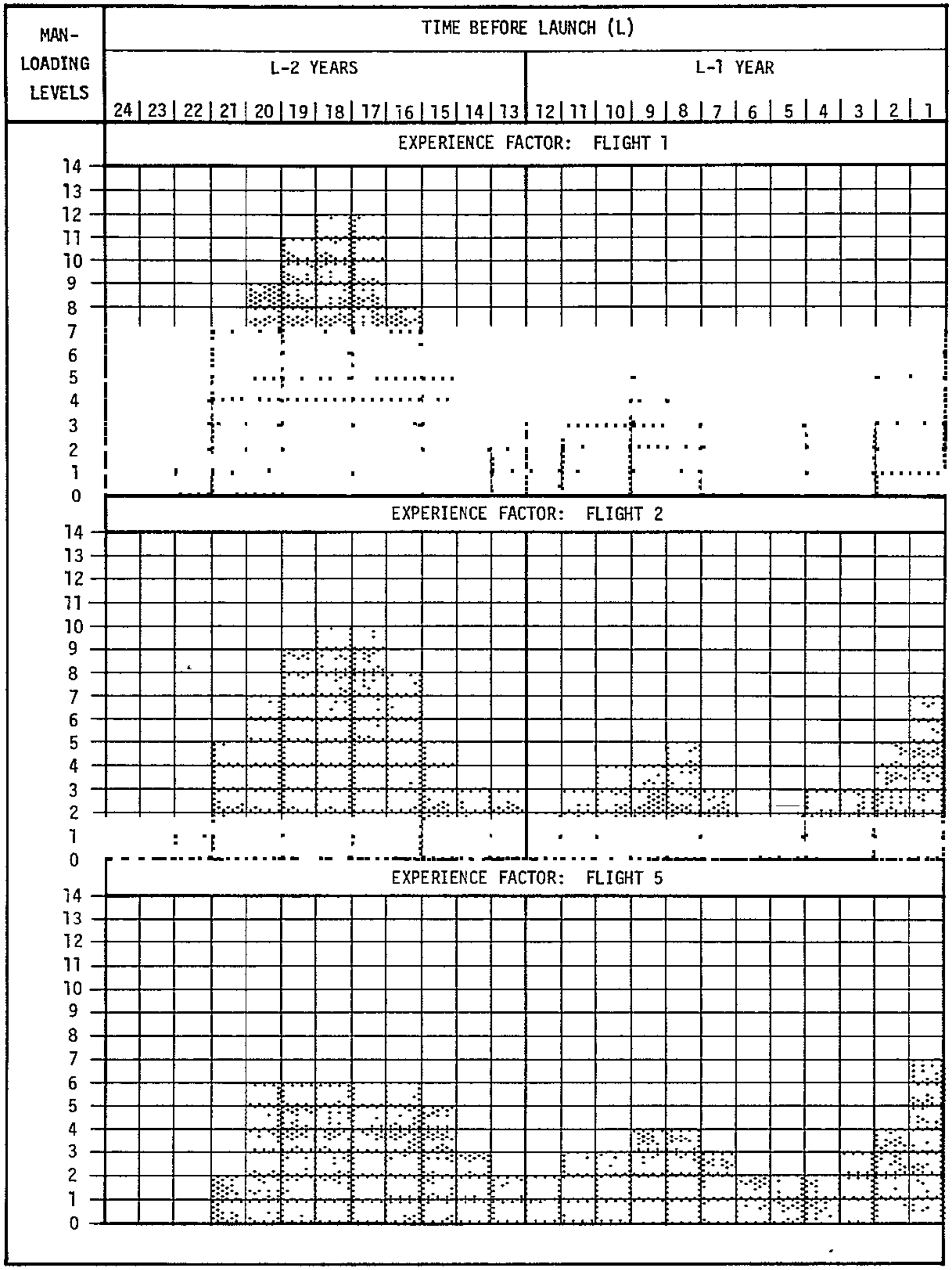

Figure 3.3-7. Spacelab Payloads 7-Day Flights, System Support (1AA2)

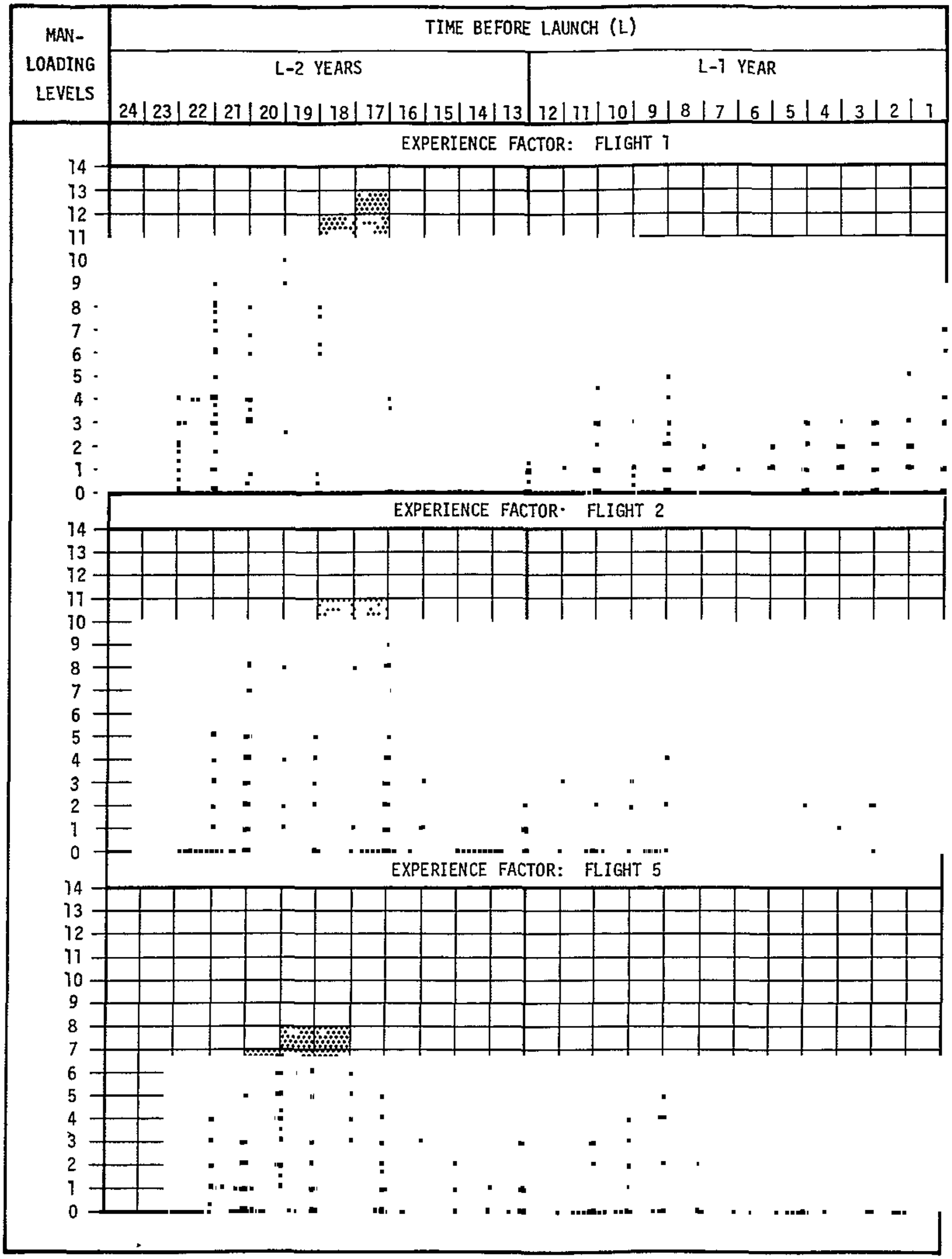

Figure 3.3-8. Spacelab Payloads 30-Day Flights, System Support (1AB2)

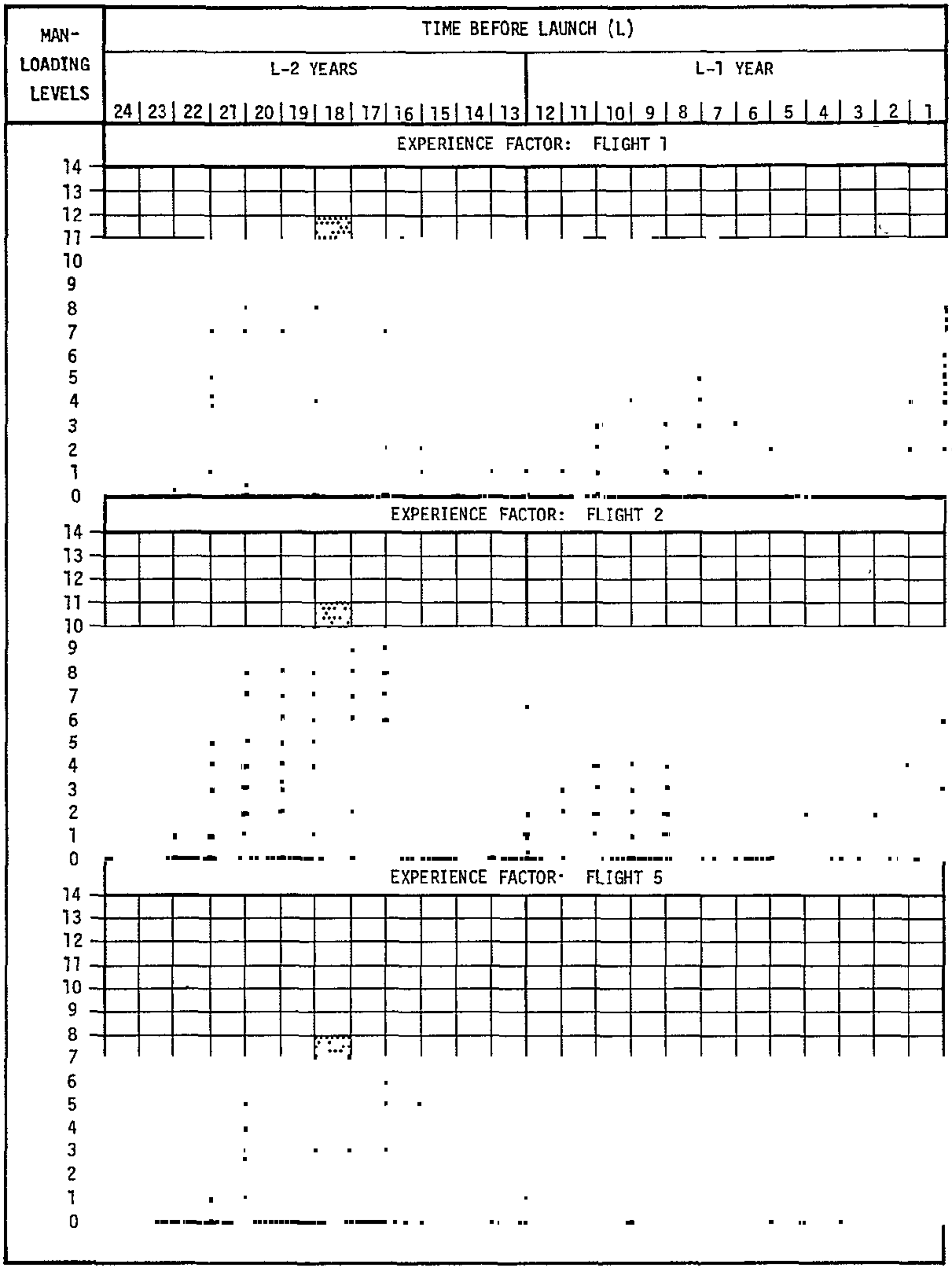

Figure 3.3-9. AEO Payloads, System Support (1B2)

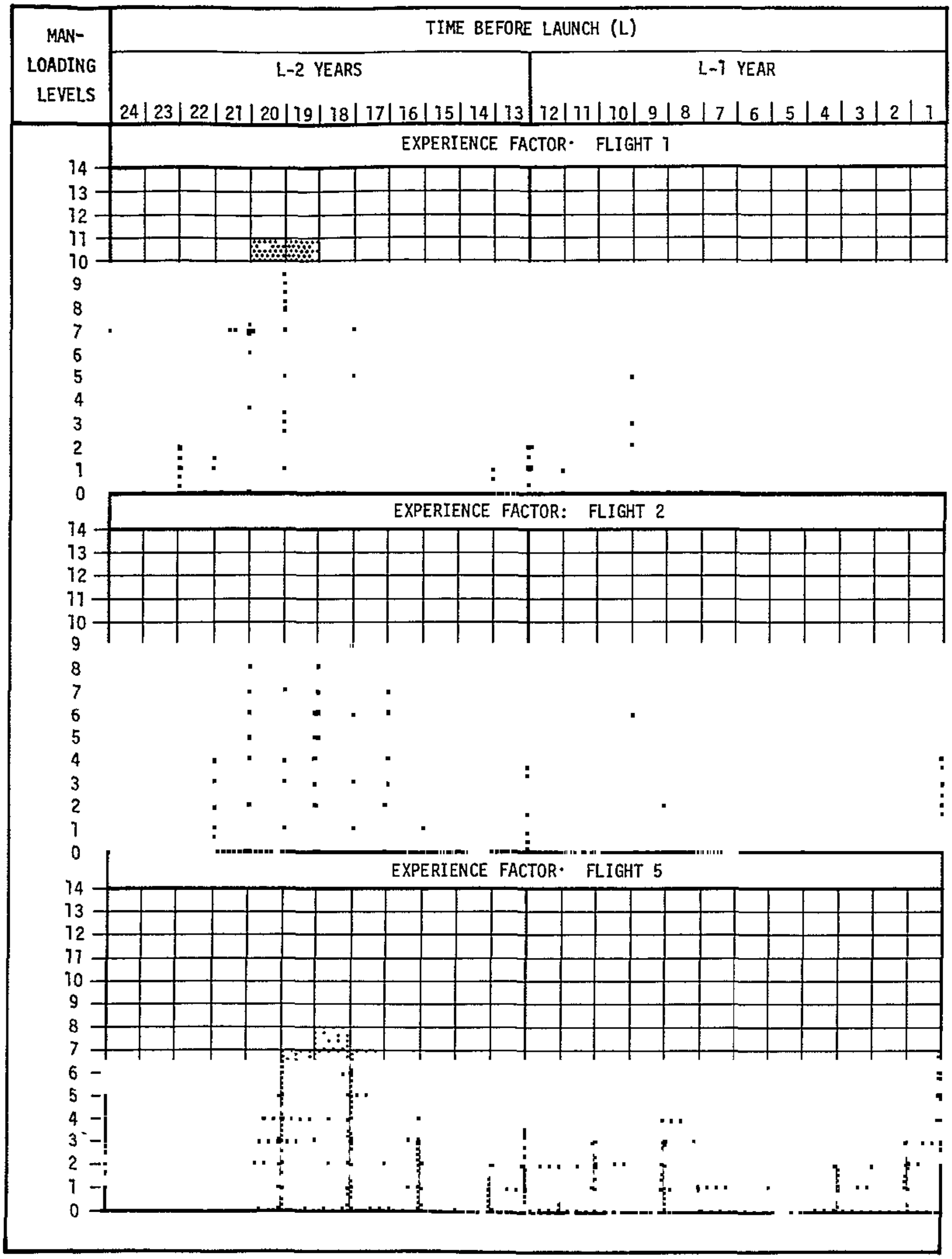

Figure 3.3-10. Planetary Payloads, System Support (1C2)

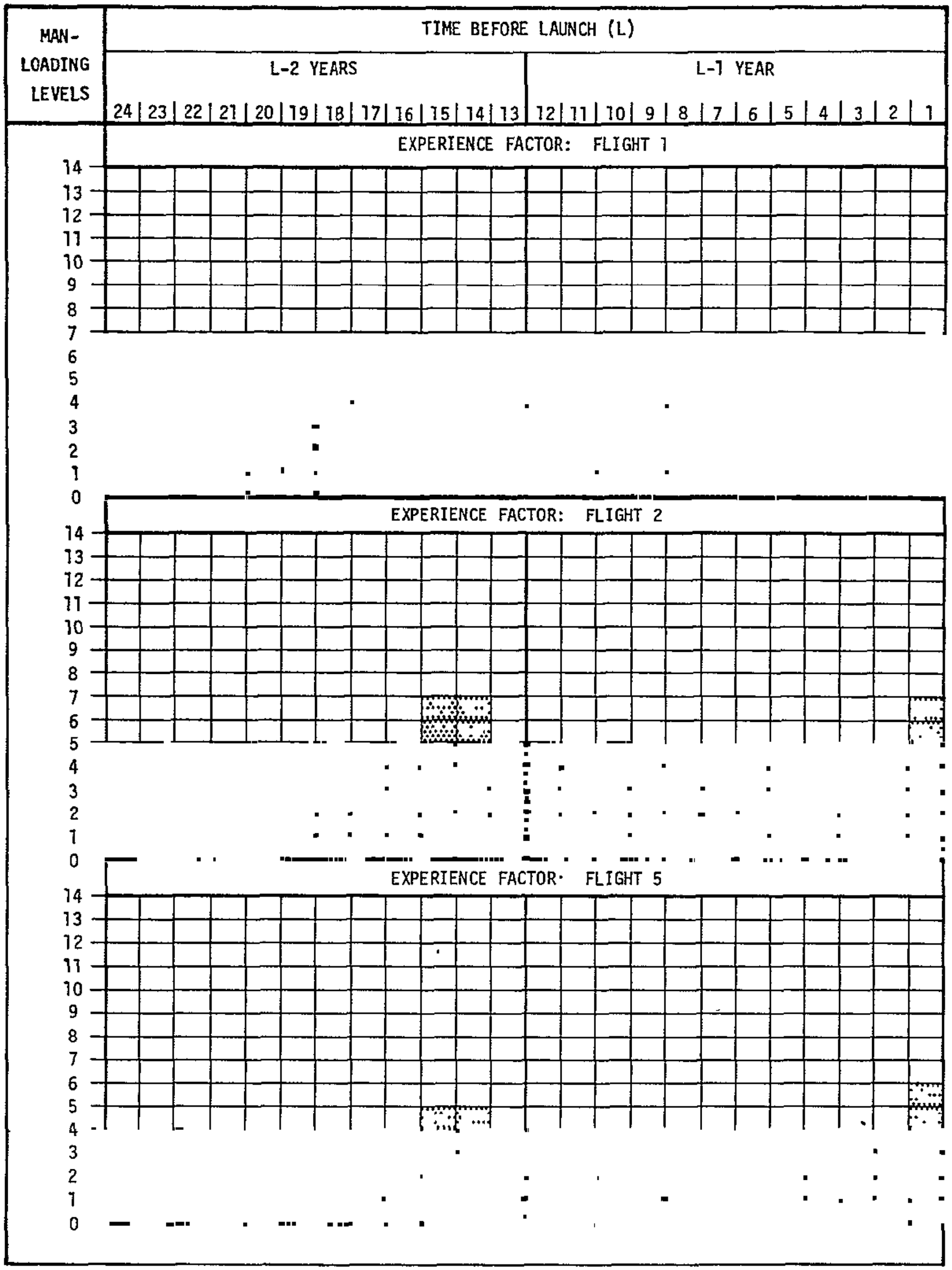

Figure 3.3-11. Spacelab Payloads 7-Day Flights, Integrated Flight Planning (1AA3)

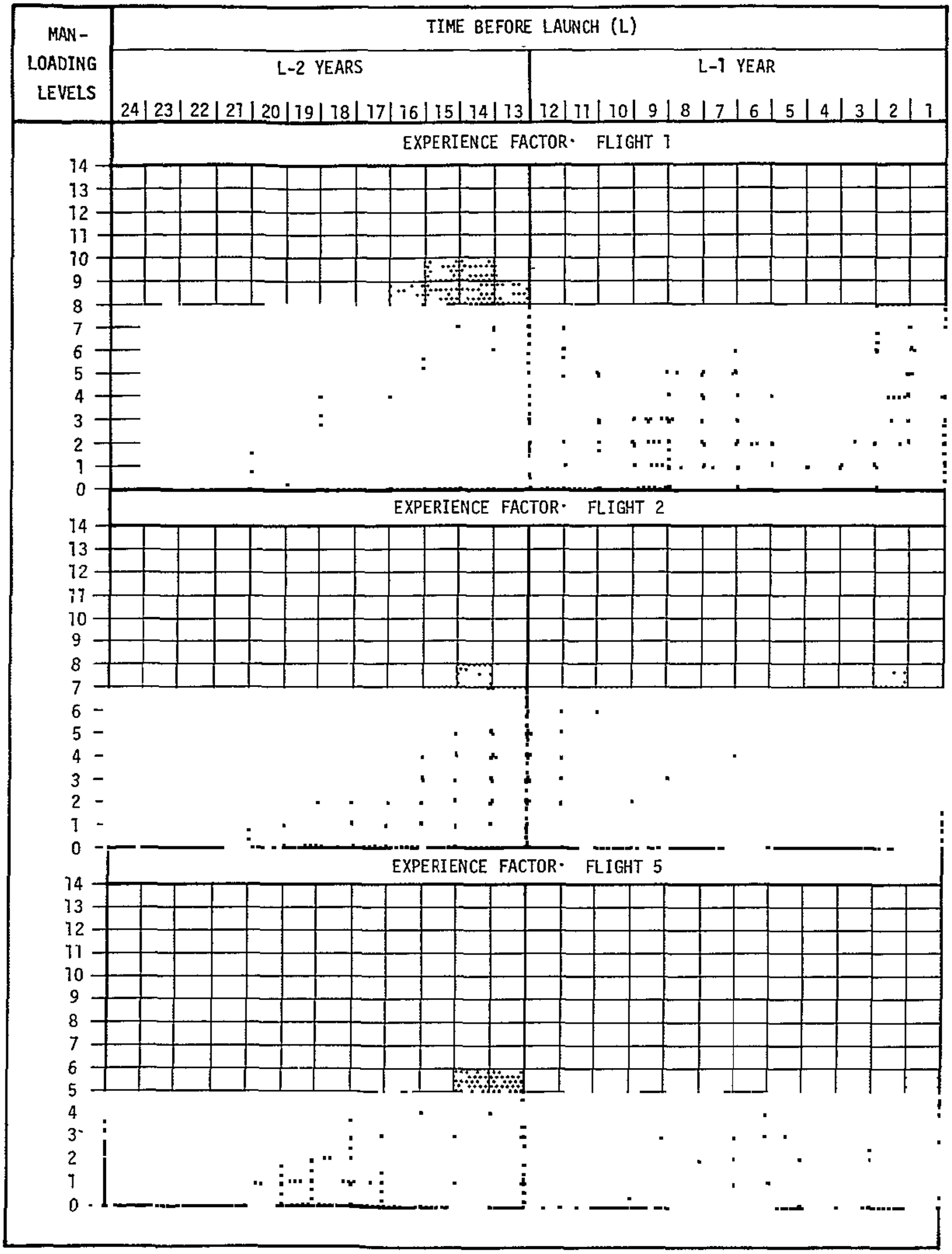

Figure 3.3-12. Spacelab Payloads 30-Day Flights, Integrated Flight Planning (1AB3)

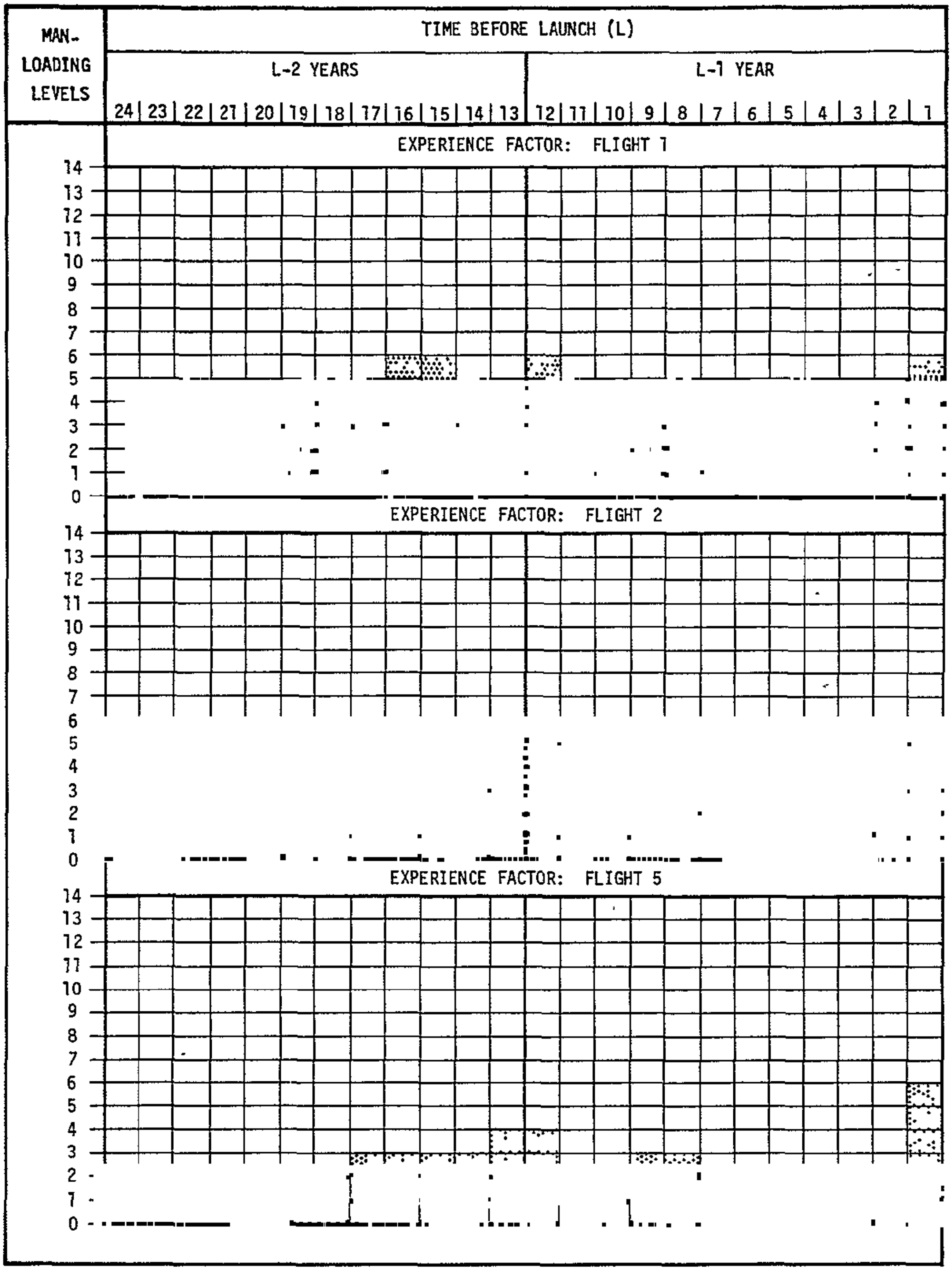

Figure 3.3-13. AEO Payloads, Integrated Flight Planning (1B3)

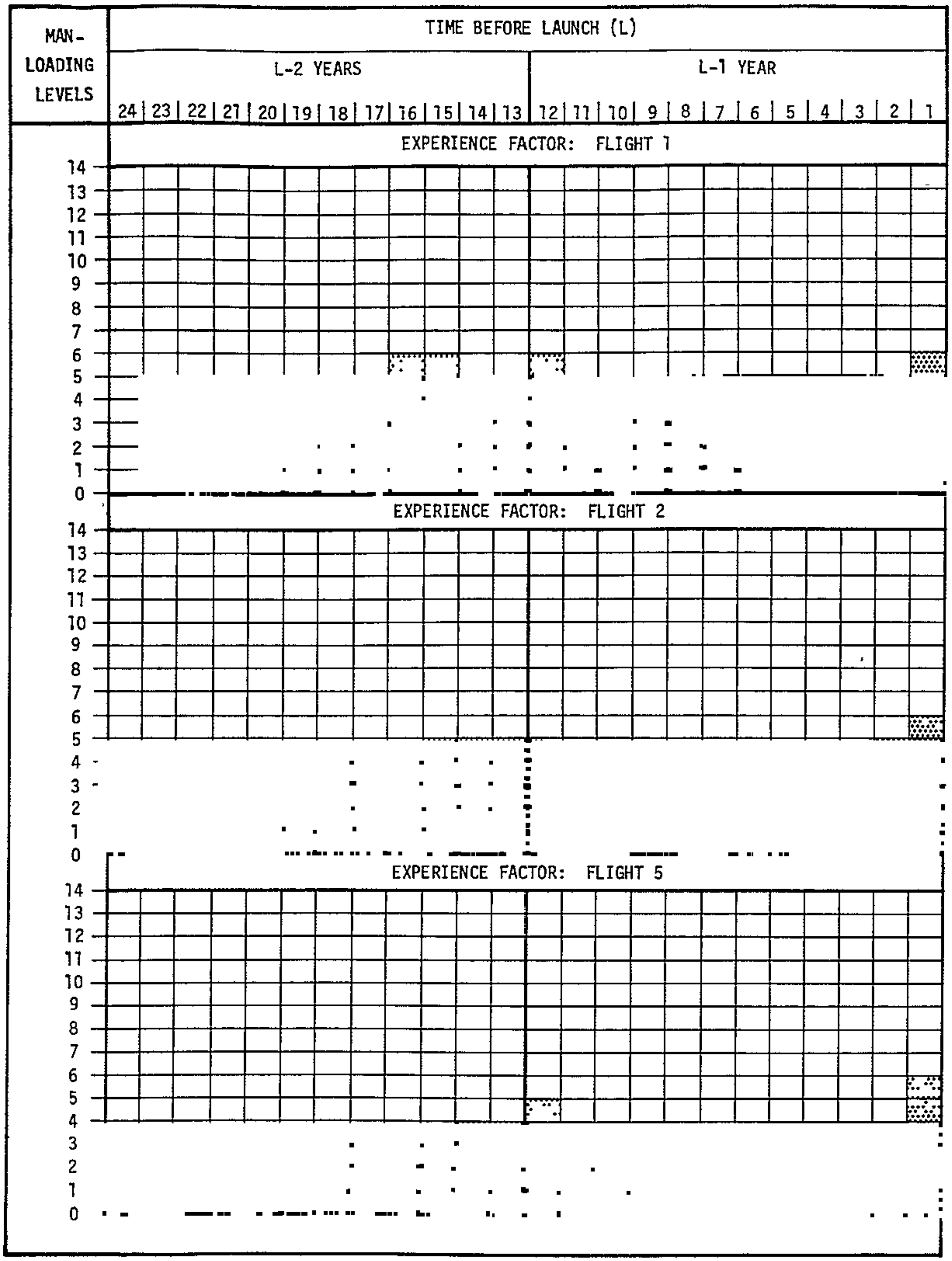

Figure 3.3-14. Planetary Payloads, Integrated Flight Planning (1C3)

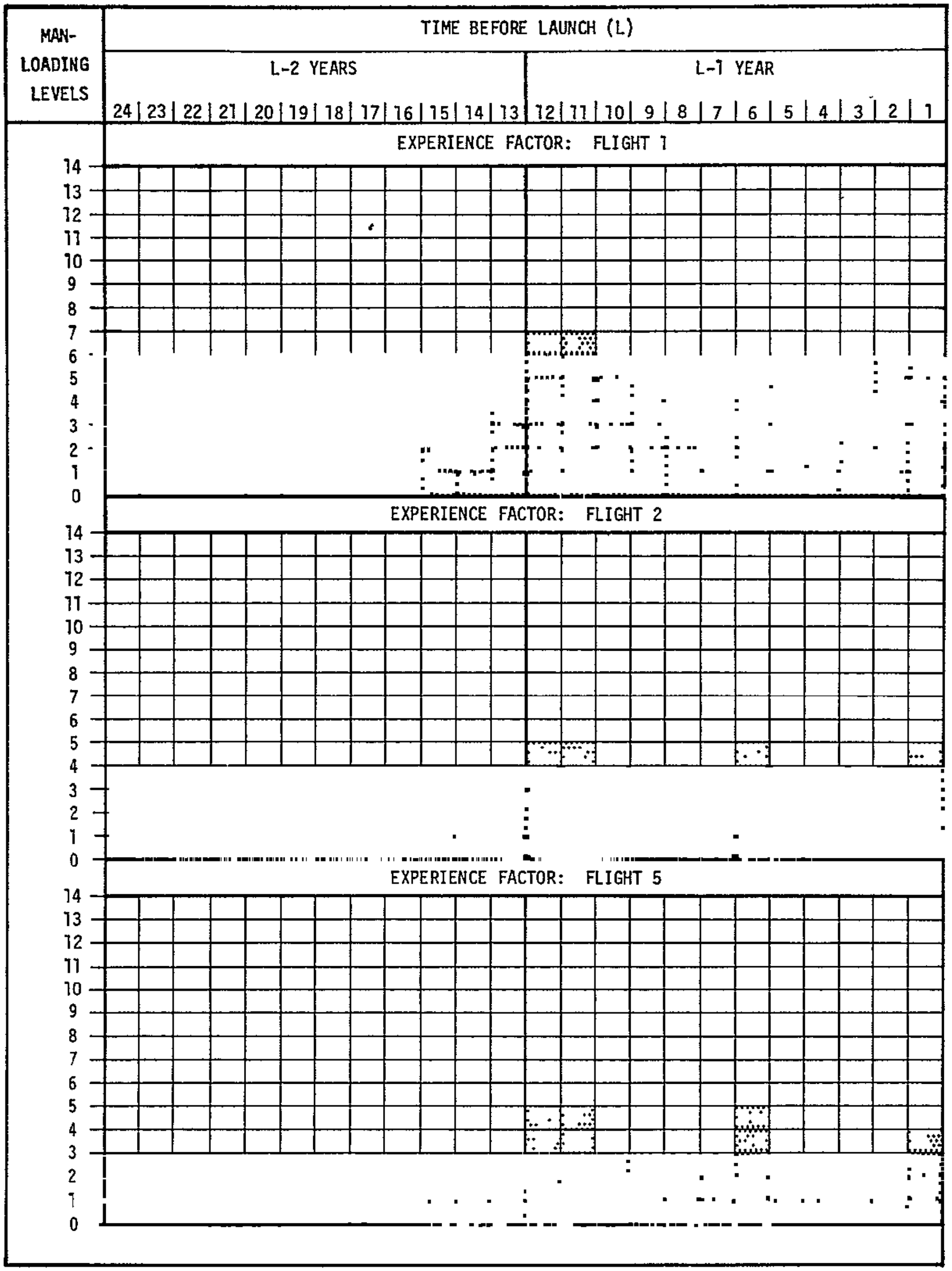

Figure 3.3-15. Spacelab Payloads 7-Day Flights, Joint Operations Planning and Procedures Development (1AA4)

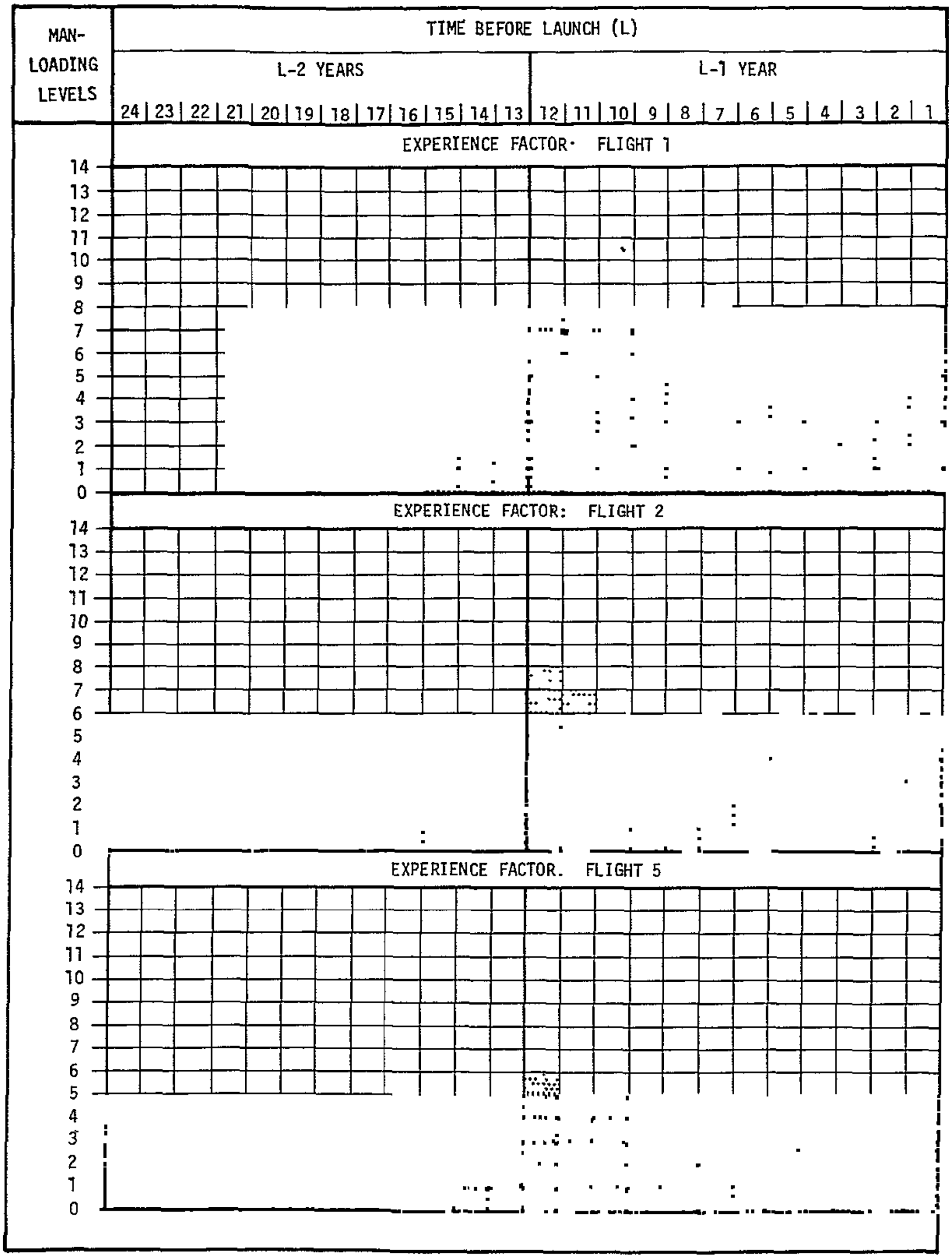

Figure 3.3-16. Spacelab Payloads 30-Day Flights, Joint Operations Planning and Procedures Development (1AB4)

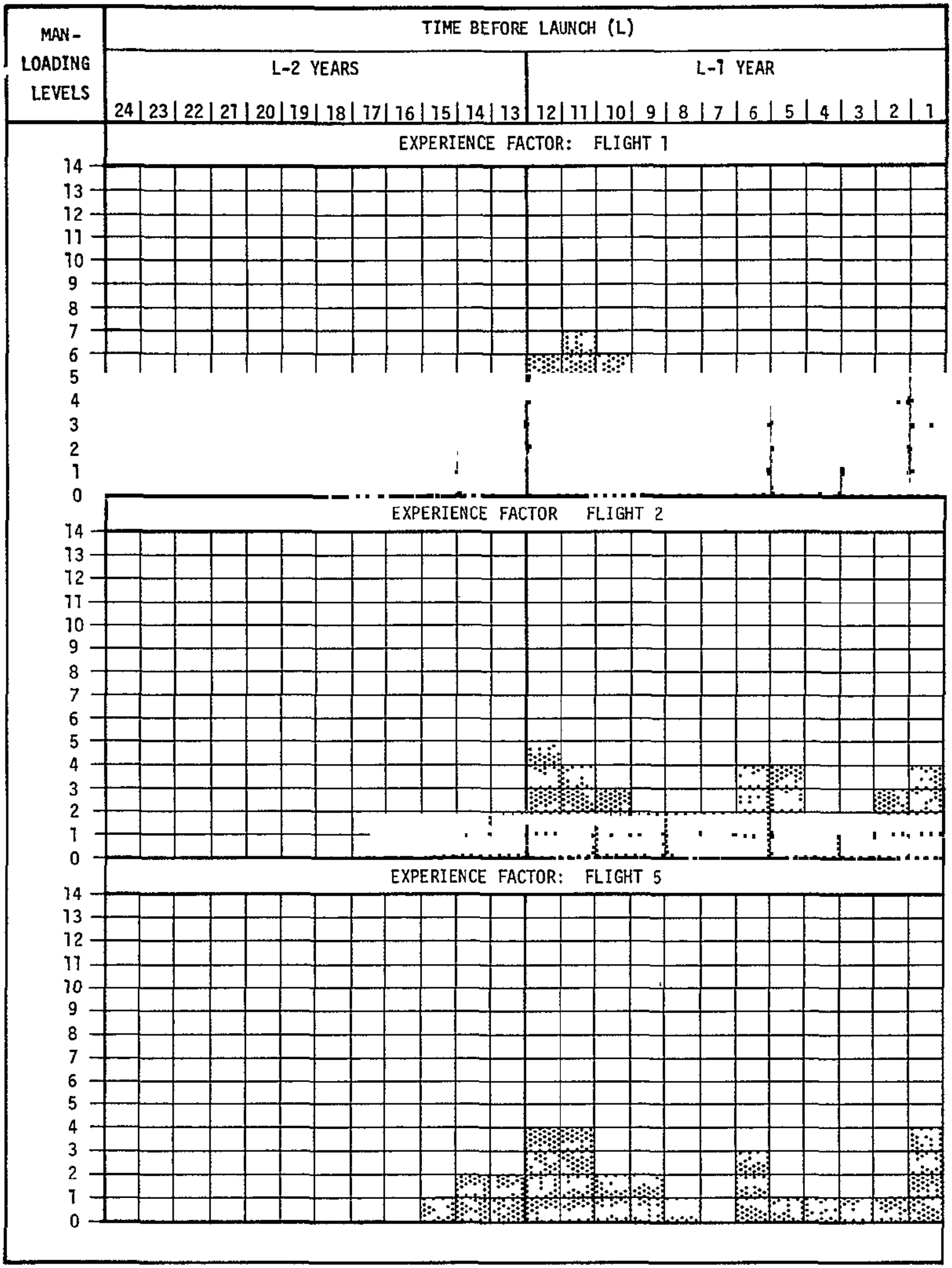

Figure 3.3-17. AEO Payloads, Joint Operations Planning and Procedures Development (1B4)

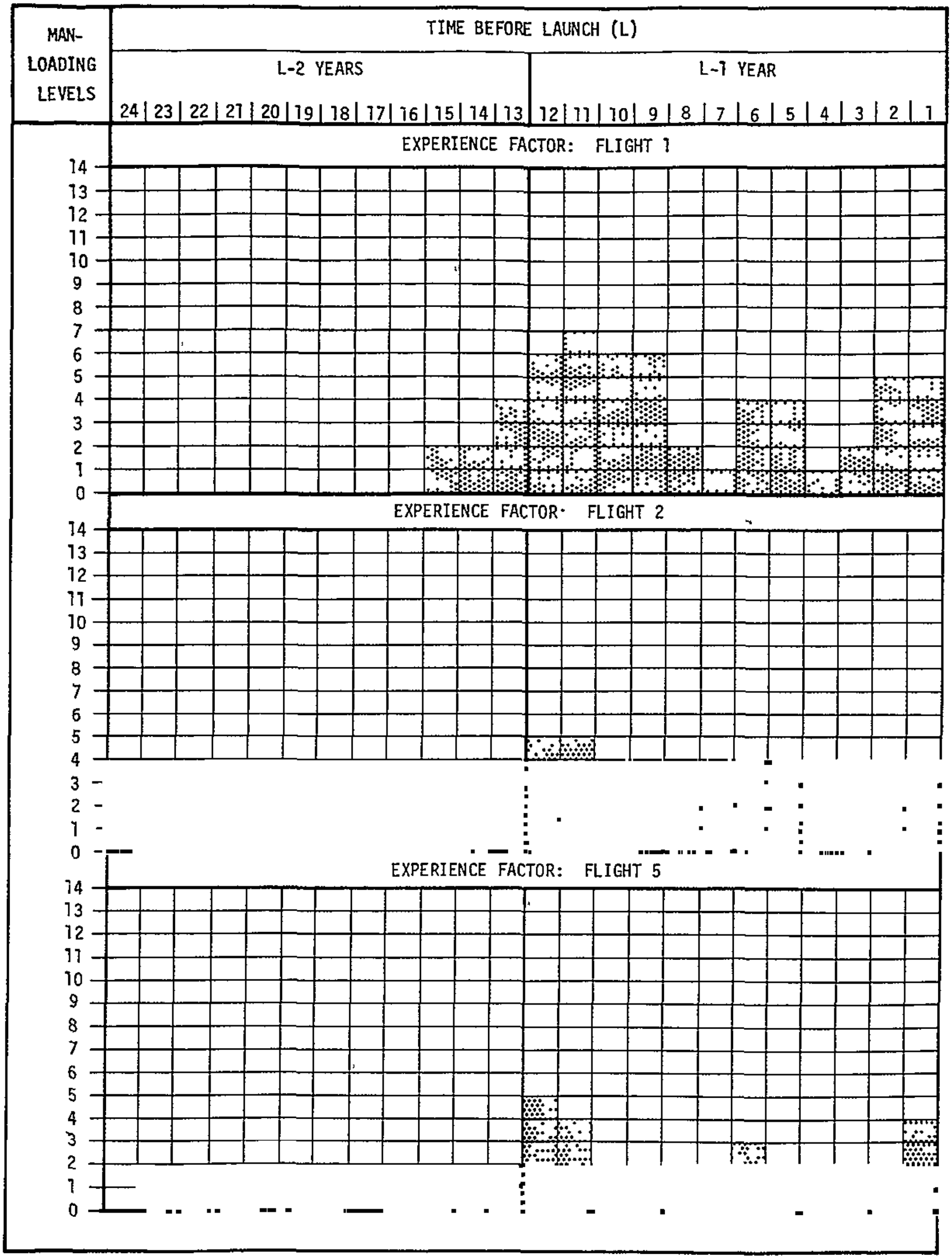

Figure 3.3-18. Planetary Payloads, Joint Operations Planning and Procedures Development (1C4)

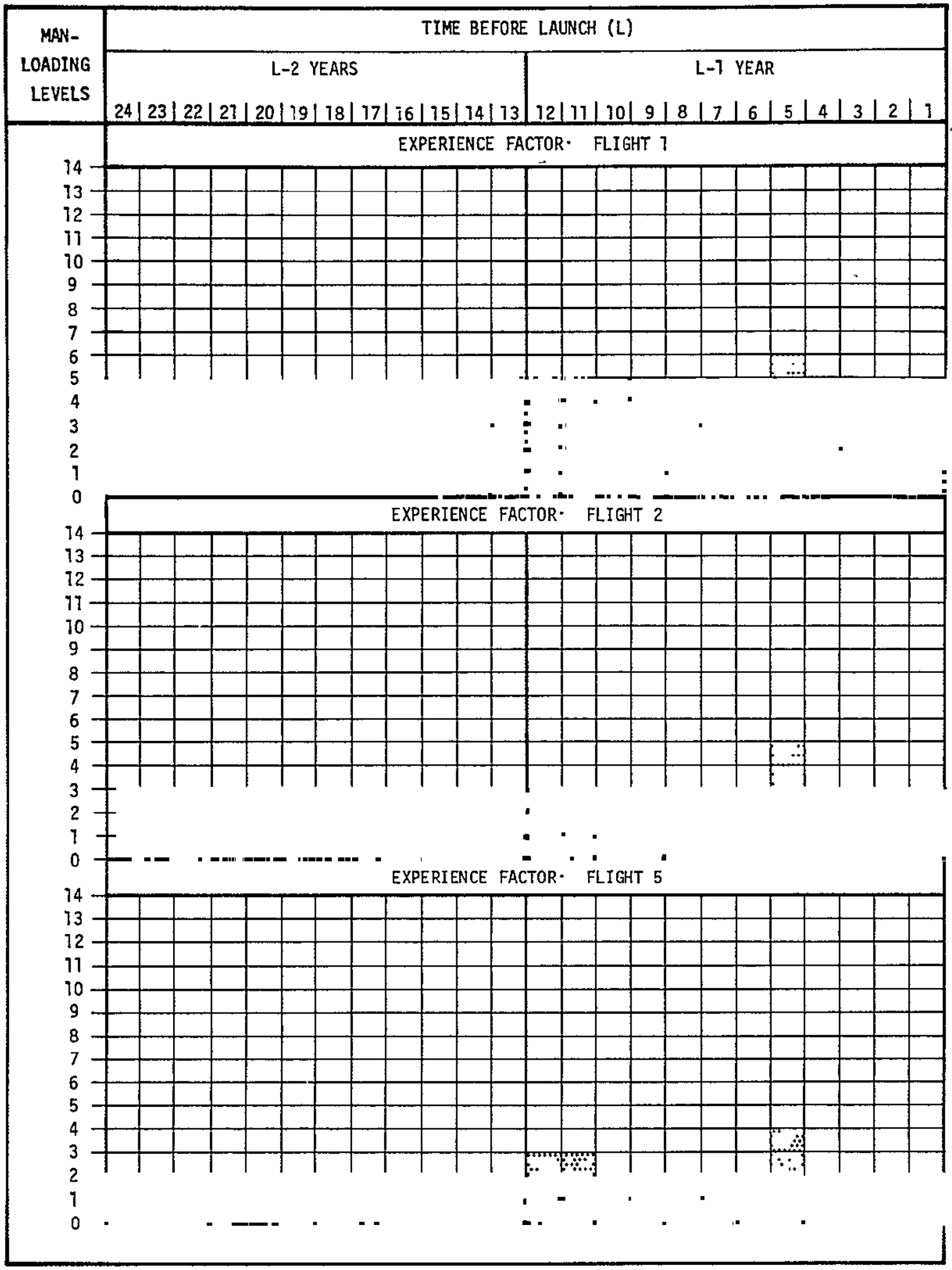

Figure 3.3-19. Spacelab Payloads 7-Day Flights, Training and Simulations (1AA5)

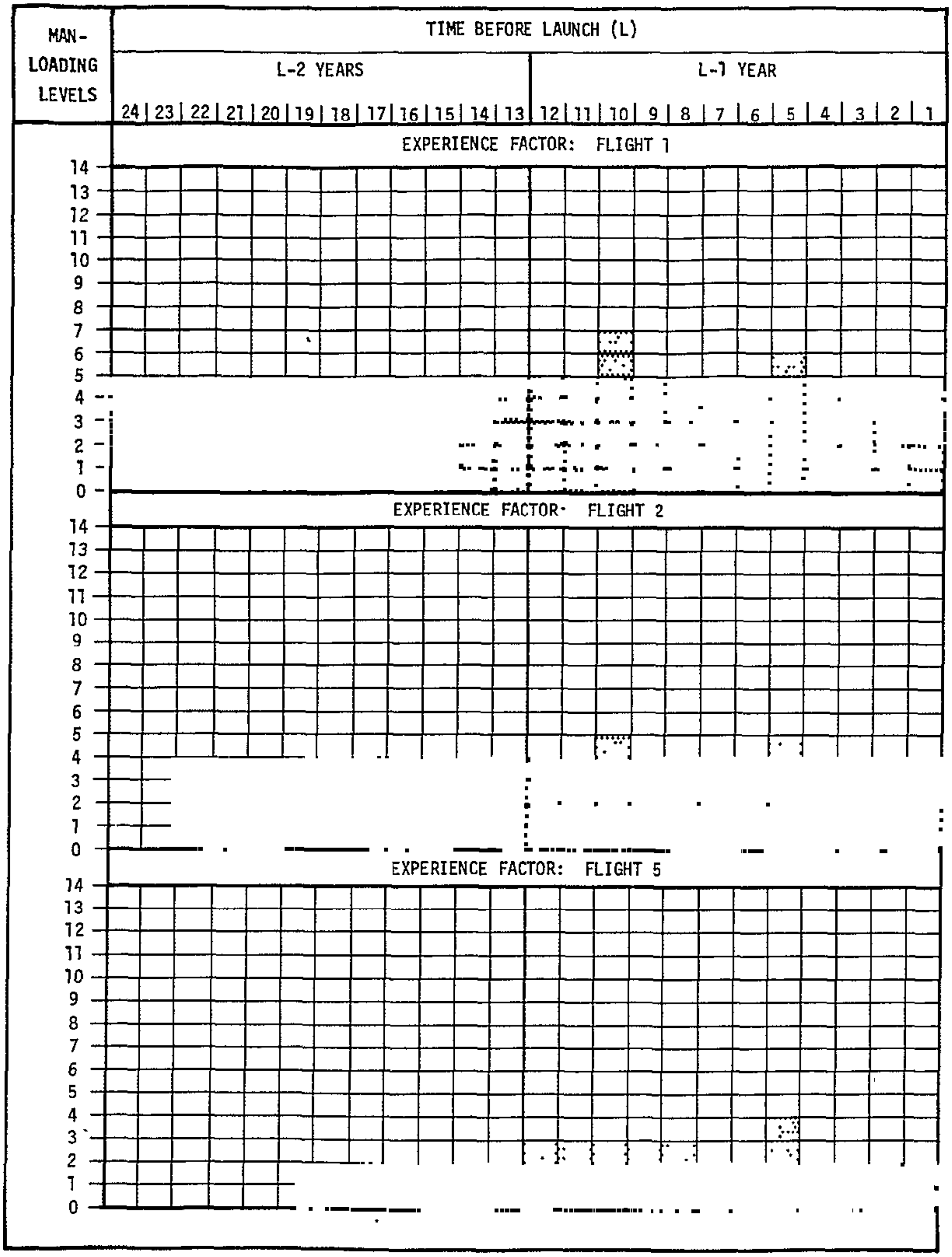

Figure 3.3-20. Spacelab Payloads 30-Day Flights, Training and Simulations (1AB5)

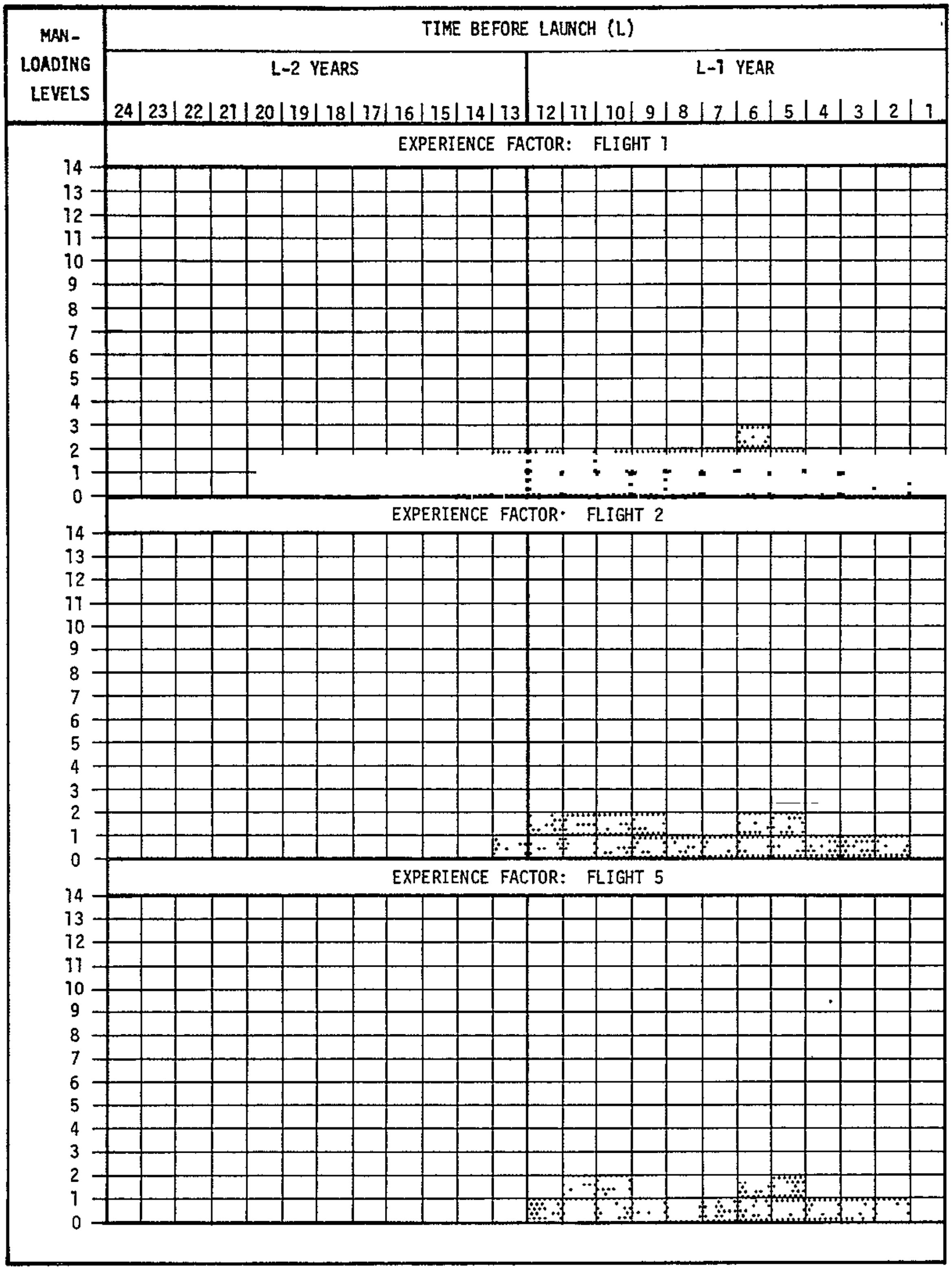

Figure 3.3-21. AEO Payloads, Training and Simulations (1B5)

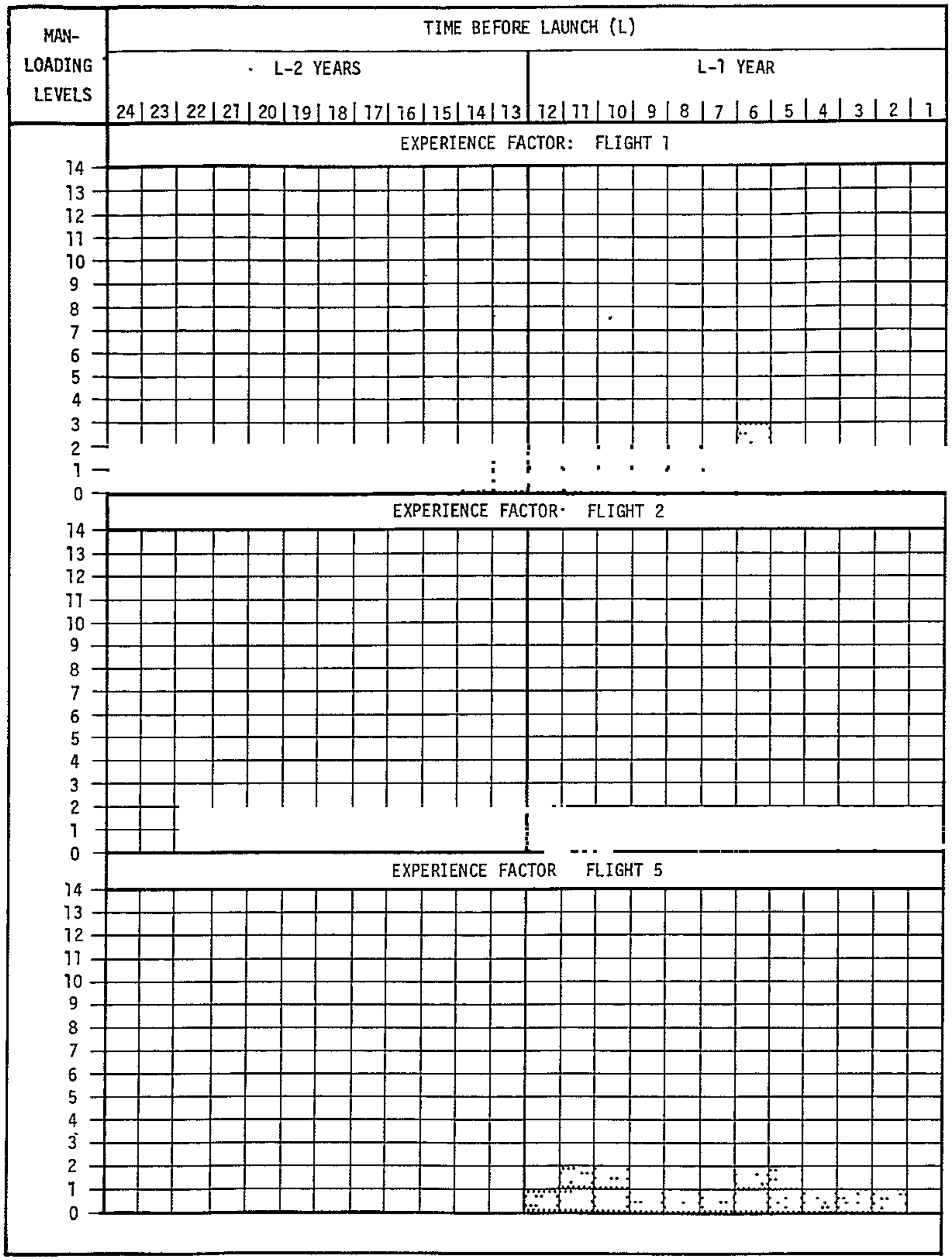

Figure 3.3-22. Planetary Payloads, Training and Simulations (1C5)

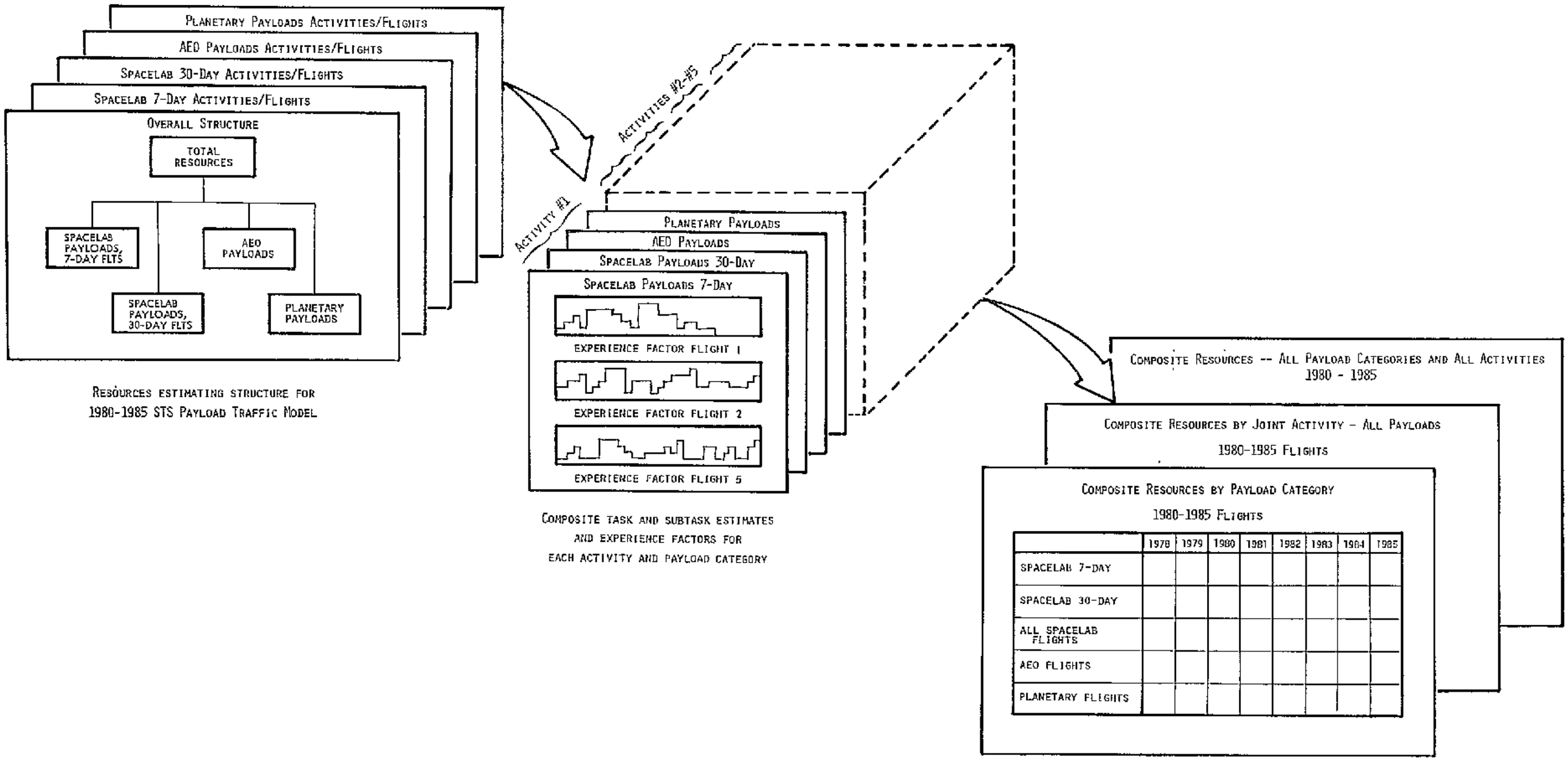

Figure 3.3-23. Approach to Summarizing Composite Resources Estimate

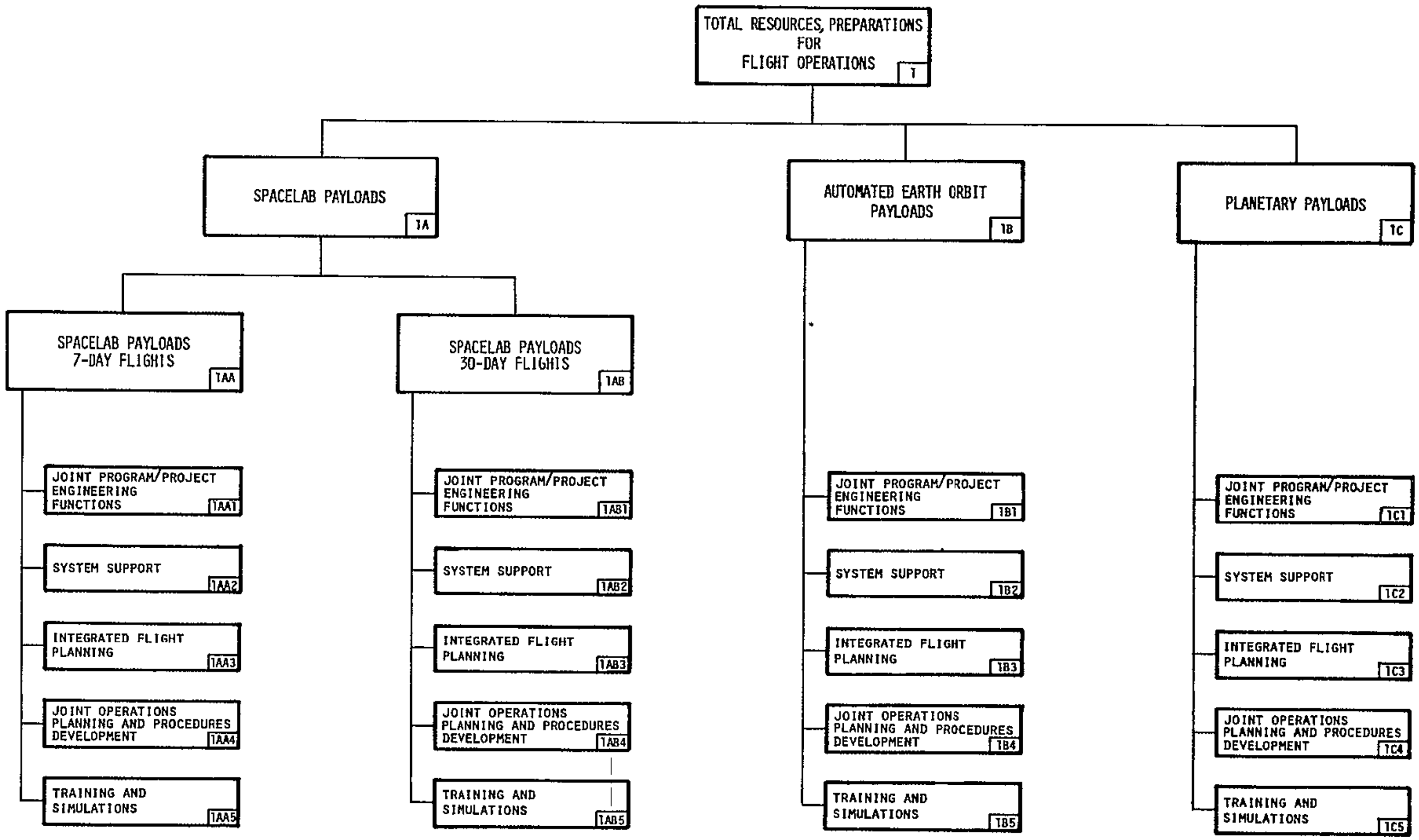

Figure 3.3-24. Resources Estimating Structure for 1980-1985 STS Payloads Traffic

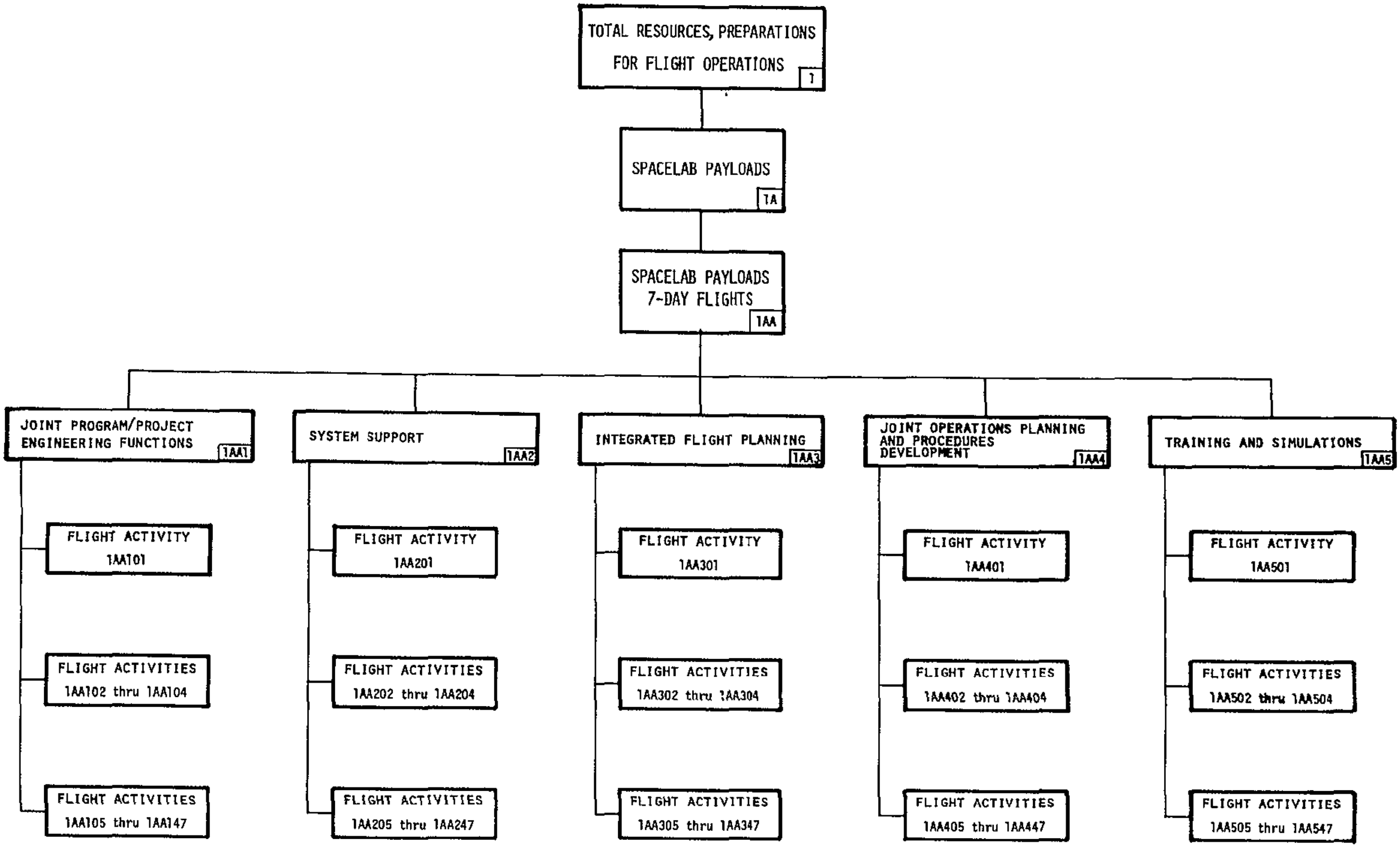

Figure 3.3-25. Resources Estimating Structure, 1980-1985 Spacelab 7-Day Flight Traffic

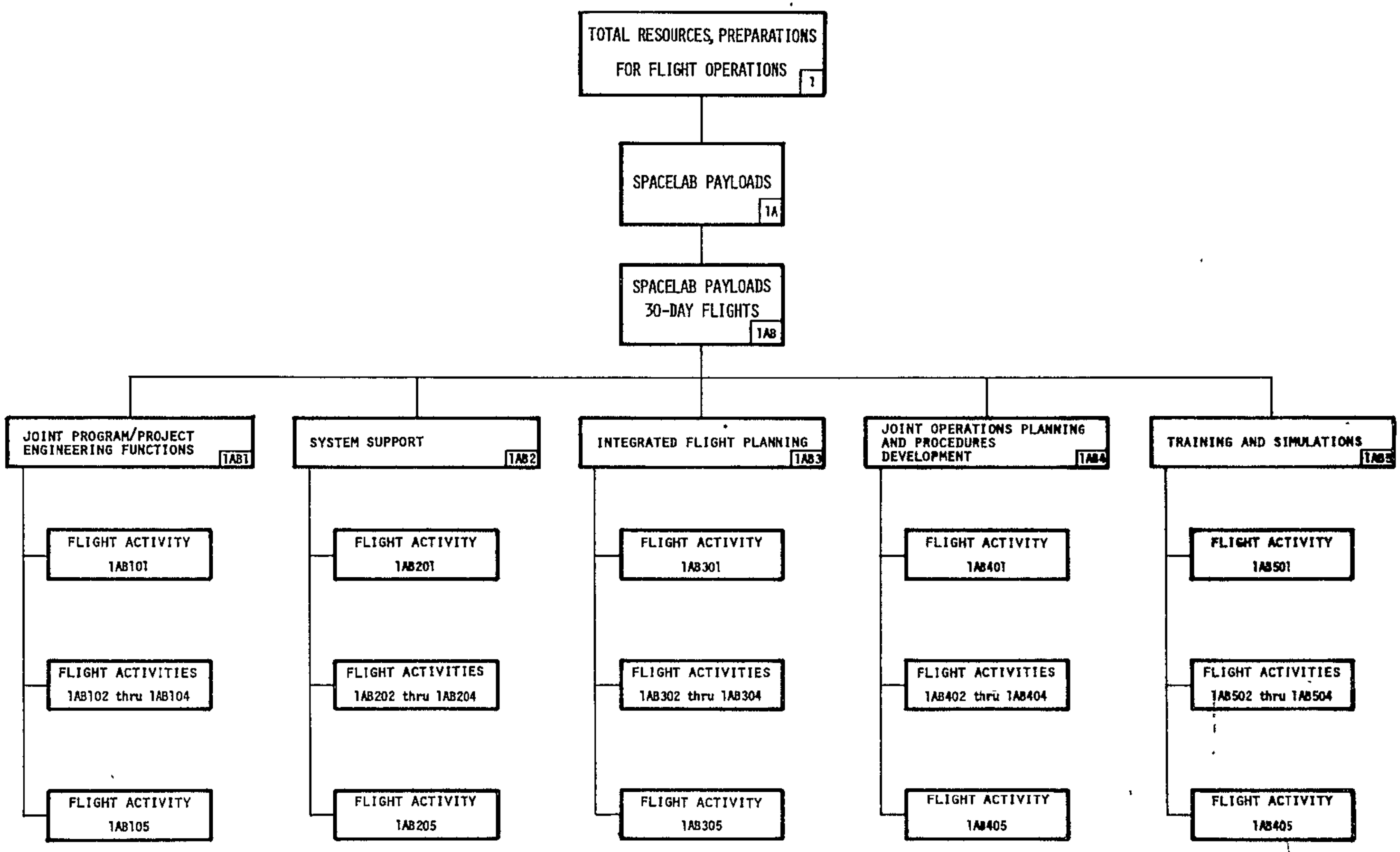

Figure 3.3-26. Resources Estimating Structure, 1980-1985 Spacelab 30-Day Flight Traffic

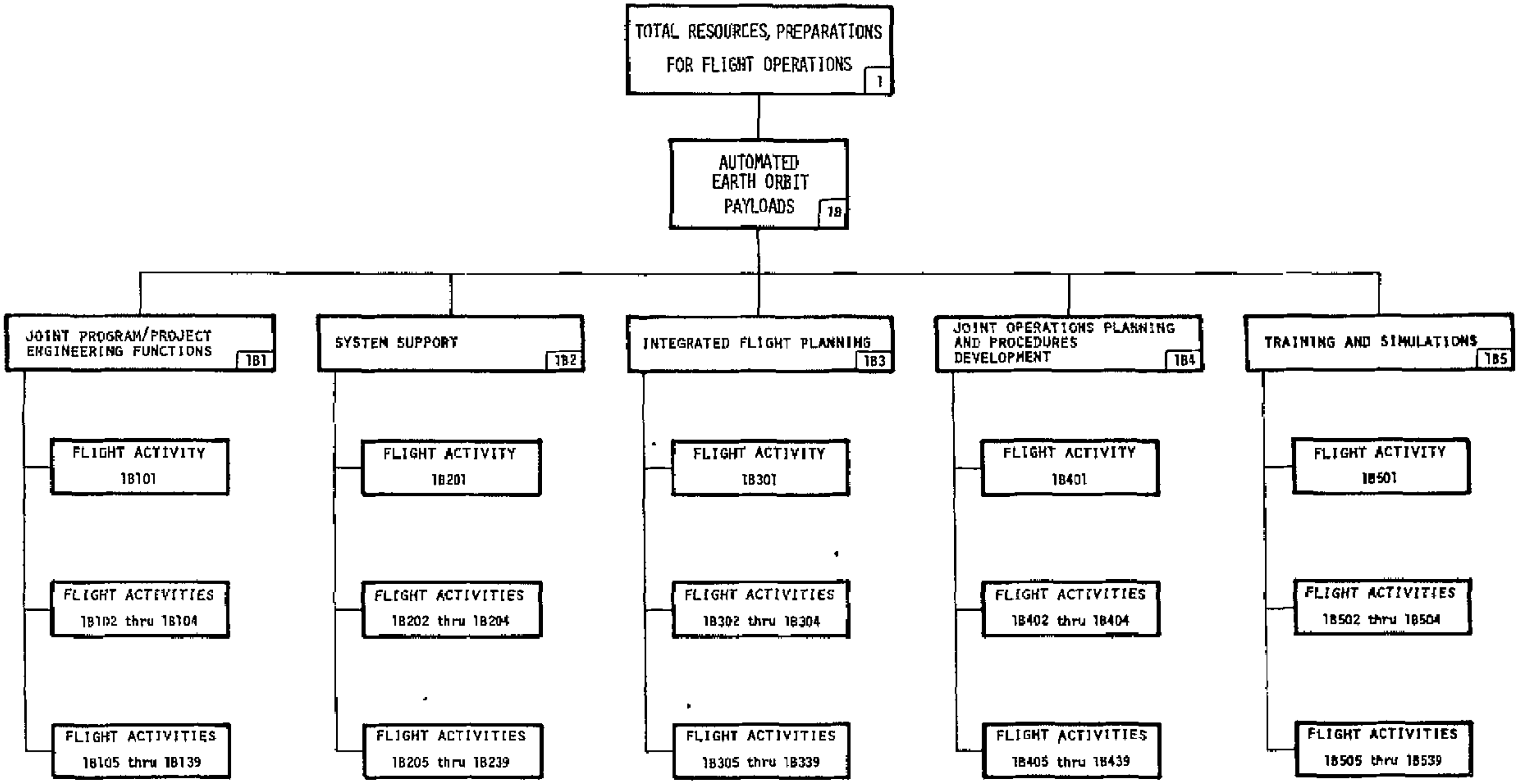

Figure 3.3-27. Resources Estimating Structure, 1980-1985 Automated Earth Orbit Flight Traffic

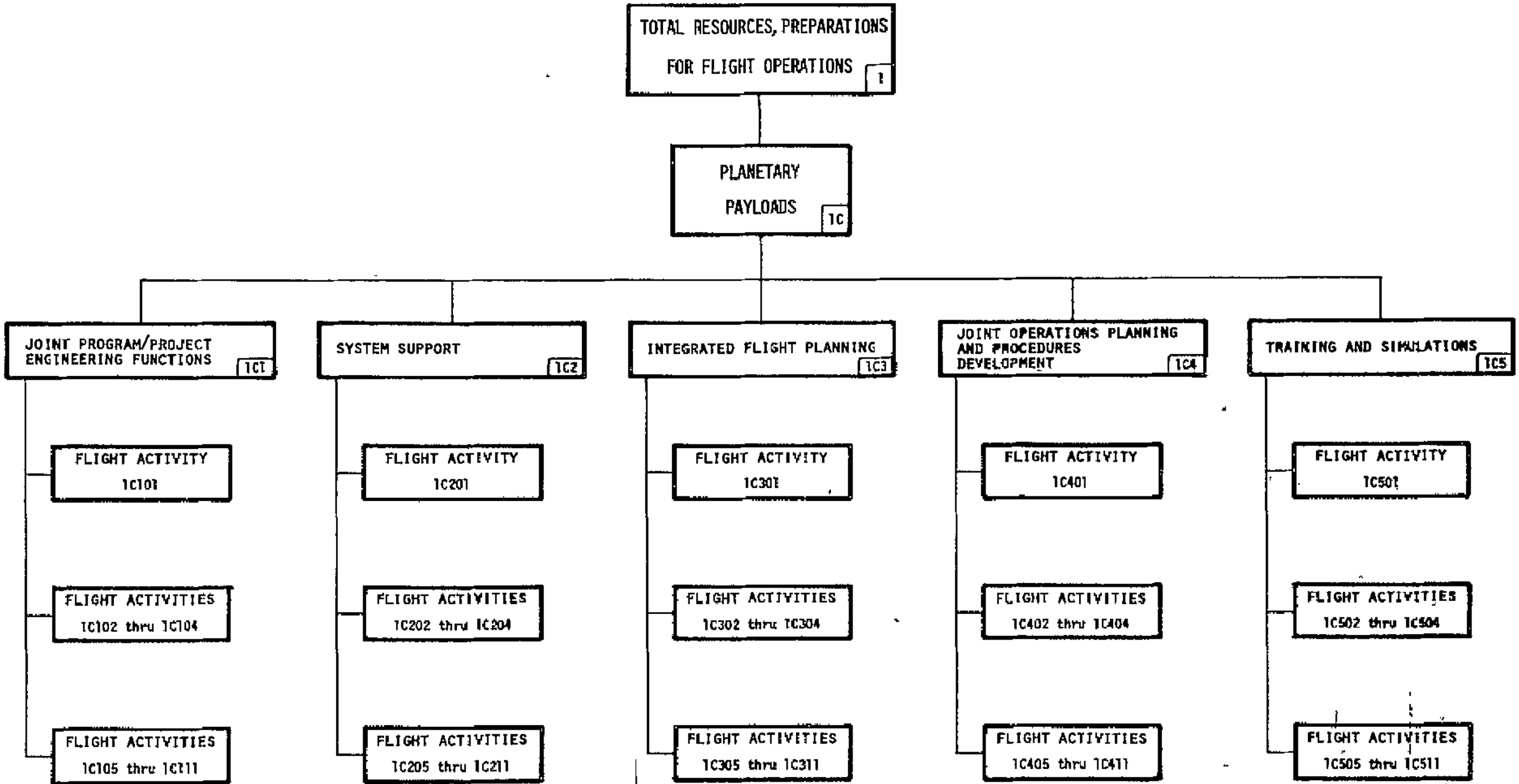

Figure 3.3-28. Resources Estimating Structure, 1980-1985 Planetary Flight Traffic

Table 3.3-8 provides a rough indication of the computation resources required for each task by payload flight category for the first flight. Table 3.3-9 shows the basis for estimating computation time.

Because of the rapidly changing computer technology, it was not considered worthwhile to estimate computer time for the later flights since the phase-in of new generation computers with greater processing speed and power will make estimates based on todays technology obsolete.

3.3.6 Task 3 Summary of Composite Resources and Analysis of Results

The charts included in this section depict the results of computer runs which utilized the data generated for the Composite Task and Subtask Estimates and Experience Factors for Each Activity and Payload Category for Flights 1, 2 and 5. Data Summaries and Summaries of Results are presented.

3.3.6.1 Summaries of Composite Resources

Figure 3.3-29, Summary of Resource Requirements, Flights 1, 2 and 5 for Joint Flight Preparation Activities, provides a summary comparing the total resource requirements for each Joint Activity with respect to each of the three experience factor flights as well as with respect to the average for all Payload categories for each experience factor flight. Also included on this chart is the total of each experience factor flight break point for each payload category.

Figure 3.3-30, Composite Resources by STS Payload Category, provides a summary plot of the total composite resources required for the total flights of each payload category per month from 1978 through 1985.

Figure 3.3-31, Composite Resources by Joint Activities, provides a summary of the total composite resources required for each activity for all payload categories per month from 1978 through 1985.

Figure 3.3-32, Total Resources, All Flight Types -- All Activities, shows the total resources required by year from 1978 through 1983 for support of STS Flights during the period 1980 through 1985.

3.3.6.2 Analysis of Results

From the data presented, it can be seen that the build up of human resources for STS Flight preparation of Joint Activities is fairly linear from 1979 through 1983. See Figure 3.3-32.

TABLE 3.3-8. SUMMARY OF COMPUTATION RESOURCES BY ACTIVITY AND TASK

ACTIVITY	TASK	PAYLOAD CATEGORIES			
		SL-7*	SL-30**	AEO***	P****
		COMPUTER HRS/FLT			
1. JOINT PROGRAM/PROJECT ENGINEERING FUNCTIONS	Joint Project Planning	8.0	10.0	6.0	6.0
	Joint Flight Requirements Development	12.0	14.0	8.0	12.0
	STS-Payload Flight Operation Data Base	15.0	18.0	12.0	10.0
	STS-Payload Flight Configuration Identification and Control	4.0	5.0	4.0	3.0
	Integrated Flight Safety Evaluation and Monitoring	3.0	4.0	2.0	2.0
	TOTAL ACTIVITY 1	42.0	51.0	32.0	33.0
2. SYSTEM SUPPORT	Communications and Data Handling	3.0	4.0	2.0	2.0
	Integrated Range Requirements	3.0	3.0	3.0	3.0
	Integrated Network Requirements	1.0	1.0	1.0	1.0
	Joint Data Processing	2.0	3.0	2.0	2.0
	Flight Software Evaluation and Modification	5.0	6.0	4.0	4.0
	Ground Software Evaluation and Modification	3.0	3.0	4.0	3.0
	Crew Systems Evaluation and Augmentation	0.0	0.0	0.0	0.0
	TOTAL ACTIVITY 2	17.0	20.0	16.0	15.0
3. INTEGRATED FLIGHT PLANNING	Trajectory Analysis and Design	20.0	24.0	16.0	20.0
	Attitude Timelining	8.0	10.0	6.0	6.0
	Integrated Crew Activity Planning	4.0	8.0	2.0	2.0
	Integrated Consumables Analysis	8.0	10.0	6.0	6.0
	Subsystem Performance Analysis	10.0	10.0	6.0	6.0
	Integrated Contingency Planning	5.0	6.0	4.0	3.0
	TOTAL ACTIVITY 3	55.0	68.0	40.0	43.0

* SL-7 = Spacelab 7-Day Flights
** SL-30 = Spacelab 30-Day Flights
*** AEO = Automated Earth Orbit Flights
**** P = Planetary Flights

TABLE 3.3-8. SUMMARY OF COMPUTATION RESOURCES BY ACTIVITY AND TASK (CONTINUED)

ACTIVITY	TASK	PAYLOAD CATEGORIES			
		SL-7*	SL-30**	AEO***	P****
		COMPUTER HRS/FLT			
4. JOINT OPERATIONS PLANNING AND PROCEDURES DEVELOPMENT	Flight Techniques Development	1.0	1.0	1.0	1.0
	Integrated Command Planning and Procedures Development	2.0	3.0	2.0	2.0
	Integrated Flight Rules Development	1.0	1.0	1.0	1.0
	Onboard/FCR/POCC Procedures, Checklists, Reference Data Development	4.0	6.0	2.0	2.0
	TOTAL ACTIVITY 4	8.0	11.0	6.0	6.0
5. TRAINING AND SIMULATIONS	Joint/Integrated Requirements Development	2.0	3.0	1.0	1.0
	Joint/Integrated Training and Simulation Planning	4.0	5.0	2.0	2.0
	Conduct Joint/Integrated Training and Simulations	15.0	18.0	10.0	8.0
	TOTAL ACTIVITY 5	21.0	26.0	13.0	11.0
GRAND TOTAL		143.0	176.0	107.0	108.0

* SL-7 = Spacelab 7-Day Flights
** SL-30 = Spacelab 30-Day Flights
*** AEO = Automated Earth Orbit
**** P= Planetary Payload

TABLE 3.3-9. BASIS FOR USAGE OF COMPUTATION RESOURCES

ACTIVITY	TASK*	AUTOMATED FUNCTIONS & COMPUTATION
1. JOINT PROGRAM/ PROJECT ENGINEERING FUNCTIONS	1	Schedules Pert Analysis Resources Estimation and Allocation
	2	Payload Grouping Optimization-Update Trajectory Simulations Pointing and Targeting Launch and Injection Windows
	3	Storage and Retrieval, Update Engineering Computations Subsystem Operations Data Mass Properties Consumables Limit Criteria
	4	Configuration Tab Runs Configuration Timelines (Stow/Unstow)
	5	Compute Safety Margins Caution and Warning Limit Data
2. SYSTEM SUPPORT	1	Confirm Joint Communications Traffic Modes, Loads and Schedules
	2	Range Safety Computations Tracking Coverage Confirmation
	3	Computer Documentation
	4	Computation of Joint Requirements
	5	Flight Software Function Simulations Support Computations Evaluate Changes
	6	Ground Software Function Simulations Support Computations Evaluate Changes
	7	No Computation

*NOTE: Tasks are identified on Table 3.3-1 in the same order listed above.

TABLE 3.3-9. BASIS FOR USAGE OF COMPUTATION RESOURCES (CONTINUED)

ACTIVITY	TASK*	AUTOMATED FUNCTIONS & COMPUTATION
3. INTEGRATED FLIGHT PLANNING	1	Joint Trajectory Computation Launch and Injection Windows Flight Simulations Development of Rendezvous and Separation Conditions Establish Guidance and Navigation Dispersions and Accuracies
	2	Optimize Pointing Targets, Attitude Rates and Accuracies Compute Attitude Timeline Analysis of Thermal, Contamination and Communication Constraints
	3	Crew Activity Timeline Scheduling Document and Update Crew Activity Timeline and Printout
	4	Compute Consumables Usage from Prior Flights Consumables Correlation, Prior and Current Flights and Update Data Base Compute Joint Loading Requirements and Redlines
	5	Thermal/ECS Modeling and Performance Joint Loads Analysis
	6	Abort Trajectories and Simulations Targeting and Guidance Values Limited Contingency Analysis Allowance
4. JOINT OPERATIONS PLANNING AND AND PROCEDURES DEVELOPMENT	1	Support Computations
	2	Integrated Command Lists and Documentation Simulate Command Sequences
	3	Update Documentation
	4	Merging and Documentation of Procedures and Check Lists
5. TRAINING AND SIMULATIONS	1	Update Training Data Bank, Certification Criteria Training and Simulations Scheduling Criteria
	2	Scheduling Training and Simulations Documentation
	3	Perform Joint Training and Simulations

*NOTE: Tasks are identified on Table 3.3-1 in the same order listed above.

ACTIVITY	STS PAYLOAD CATEGORY												AVERAGE FOR ALL PAYLOAD CATEGORIES TOTAL MAN-MONTHS		
	SPACELAB 7-DAY FLIGHTS TOTAL MAN-MONTHS			SPACELAB 30-DAY FLIGHTS TOTAL MAN-MONTHS			AEO FLIGHTS TOTAL MAN-MONTHS			PLANETARY FLIGHTS TOTAL MAN-MONTHS					
	EXPERIENCE FACTOR			EXPERIENCE FACTOR			EXPERIENCE FACTOR			EXPERIENCE FACTOR			EXPERIENCE FACTOR		
	FLIGHT 1	FLIGHT 2	FLIGHT 5	FLIGHT 1	FLIGHT 2	FLIGHT 5	FLIGHT 1	FLIGHT 2	FLIGHT 5	FLIGHT 1	FLIGHT 2	FLIGHT 5	FLIGHT 1	FLIGHT 2	FLIGHT 5
1. JOINT PROGRAM/PROJECT ENGINEERING FUNCTIONS	1AA101* 102	1AA102 78	1AA105 55	1AB101 123	1AB102 100	1AB105 65	1B101 99	1B102 80	1B105 57	1C101 90	1C102 71	1C105 51	104	82	57
2. SYSTEM SUPPORT	1AA201 121	1AA202 106	1AA205 81	1AB201 138	1AB202 115	1AB205 92	1B201 123	1B202 105	1B205 84	1C201 115	1C202 97	1C205 81	124	106	85
3. INTEGRATED FLIGHT PLANNING	1AA301 93	1AA302 82	1AA305 62	1AB301 120	1AB302 100	1AB305 81	1B301 65	1B302 55	1B305 38	1C301 71	1C302 58	1C305 42	87	74	56
4. JOINT OPERATIONS PLANNING AND PROCEDURES DEVELOPMENT	1AA401 65	1AA402 51	1AA405 36	1AB401 74	1AB402 62	1AB405 45	1B401 55	1B402 40	1B405 29	1C401 57	1C402 42	1C405 30	63	49	35
5. TRAINING AND SIMULATIONS	1AA501 50	1AA502 39	1AA505 28	1AB501 58	1AB502 47	1AB505 36	1B501 23	1B502 18	1B505 15	1C501 23	1C502 18	1C505 15	39	31	24
SUM, ALL ACTIVITIES PER FLIGHT	431	356	262	513	424	319	365	298	223	356	286	219	417	342	257

*SAMPLE TABLE ENTRY INTERPRETATION "1AA101 102" means 102 manmonths are estimated to accomplish Joint Program/Project Engineering Functions prior to Flight 1 of Spacelab 7-Day Flight. See Figures 3.3-24 thru 3.3-28 for all Activity-STS Payload Category Codes

Figure 3.3-29. Summary of Resource Requirements, Flights 1, 2 and 5

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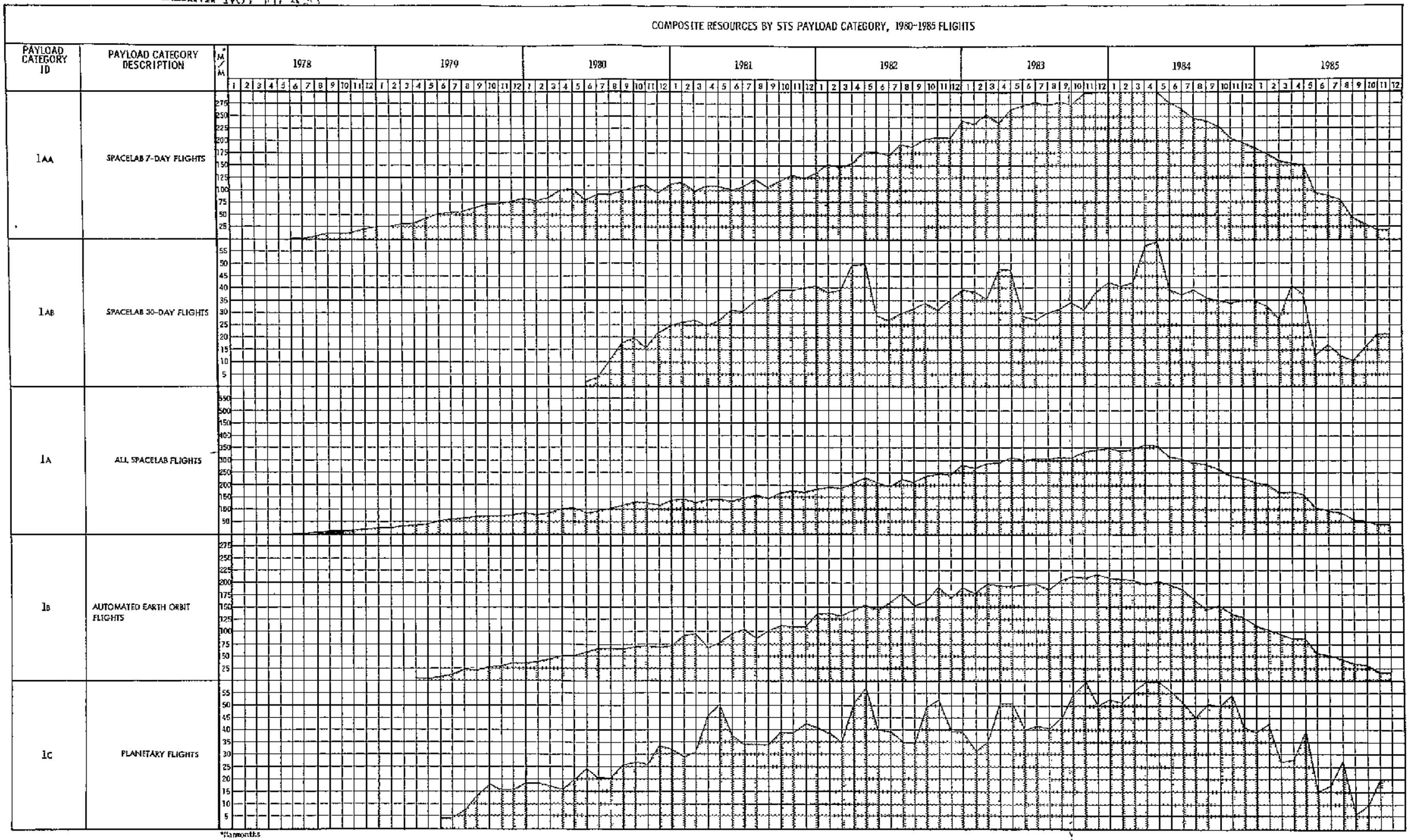

(NOTE DIFFERENCES IN MANMONTH SCALES)

NOTE Flights after 1985 were not manloaded per Study Task 3 guidelines - only thru 1985

Figure 3.3-30. Composite Resources by STS Payload Category

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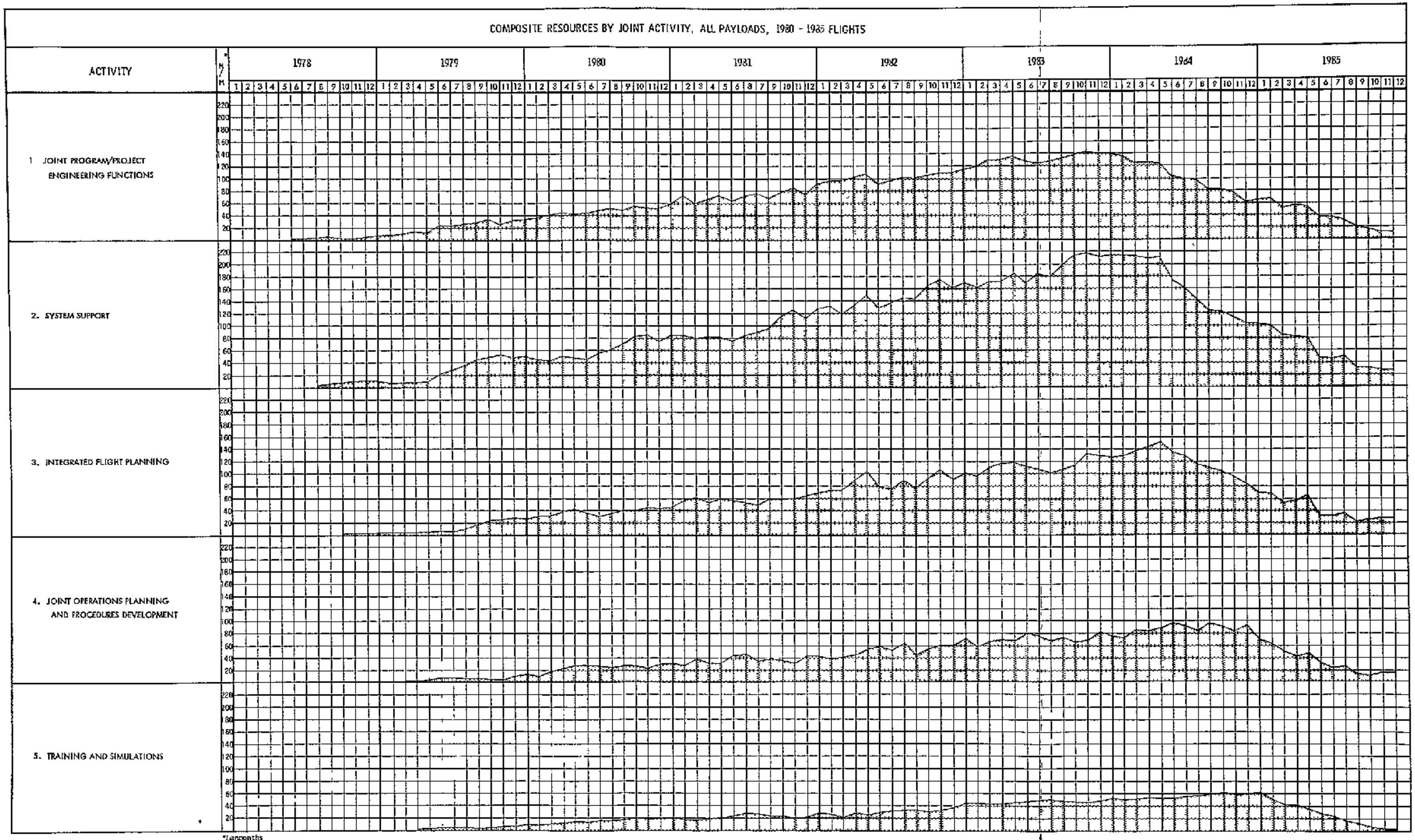

Figure 3.3-31. Composite Resources by Joint Activities

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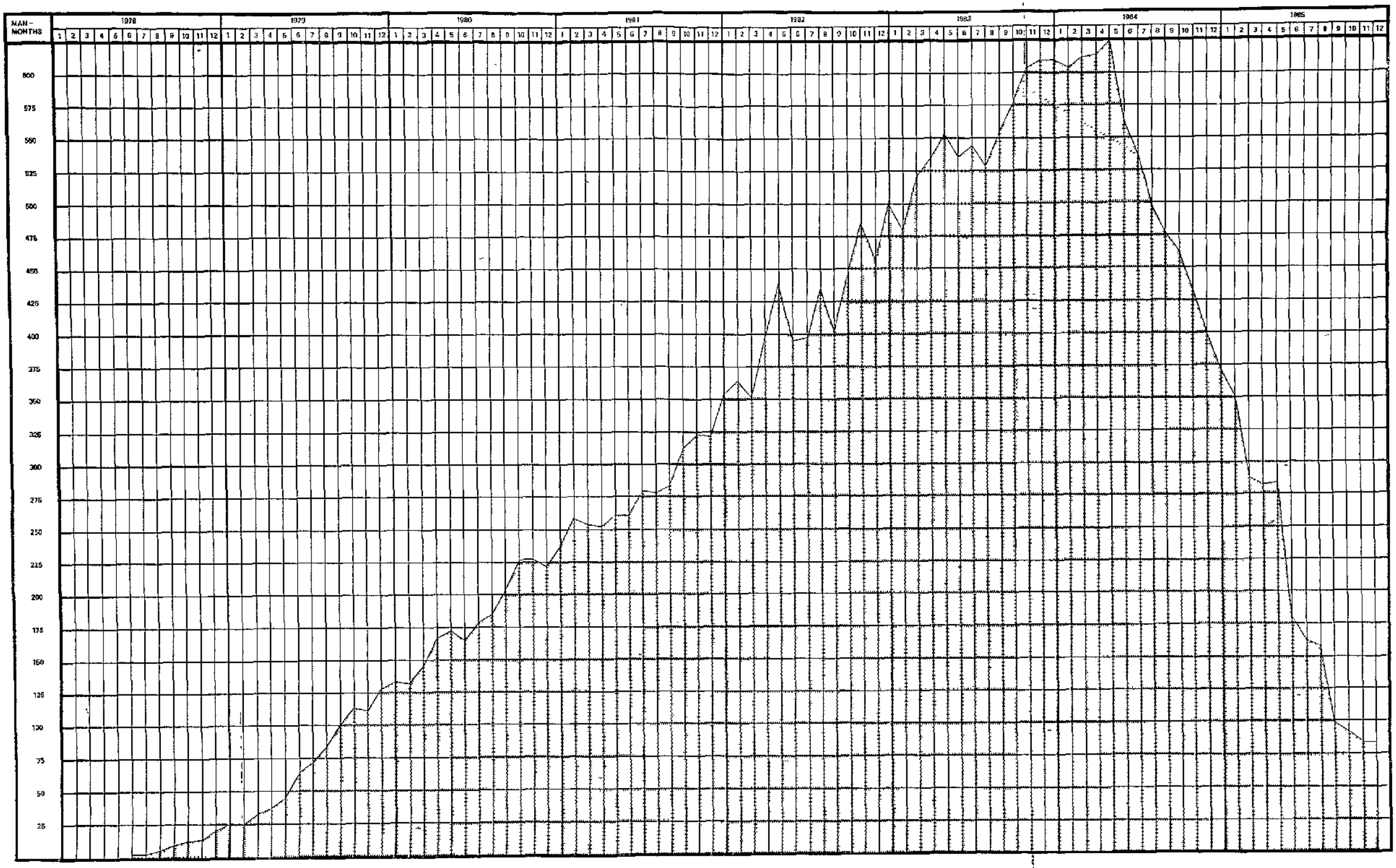

Figure 3.3-32. Total Resources, All Flight Types -- All Activities

68 + 70

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It should be noted that all of the charts showing time phased manpower over the period 1978 through 1985, depict the actual requirements for personnel through 1983. The data on the plots shown during 1984 and 1985 do not represent the total resources required during these years since all curves represent the resources required during the period beginning 24 months prior to each flight and only the launches through 1985 have been used for this analysis.

From the presentation of manpower curves for each payload type, activity and experience factor (Figures 3.3-3 through 3.3-22), it is easy to compare the reduction in manpower that occurs for each activity as a result of the experience gained between Flights 1 and 2, and likewise between Flights 2 and 5. As can be seen from these charts, the general shape of the manpower curve remains the same from flight to flight. However, the reduction in manpower due to learning curves allows a later starting date on some activities from one experience factor to the next, as well as permitting a reduction in the levels of manning.

Figure 3.3-29, Summary of Resources Requirements, Flights 1, 2 and 5, allows a direct numerical comparison of the difference in resources required for Flights 1, 2 and 5, for each joint activity and each flight type. The last column on this figure provides the average manpower for each activity and each experience factor among all the flight types. This will permit resources planning personnel to compare the resource requirements for an activity within a given flight type with the average for that activity for all flight types. It will be noted from the sum of the averages in the bottom right hand columns, that the average resources for all activities and flight types is 15% less for Flight 2 than Flight 1 and 25% less for Flight 5 than for Flight 2. Flight 5 is 38% less than Flight 1.

Figure 3.3-30, Composite Resources by STS Category, is an unsmoothed curve showing manpower by month for each flight type and for all Spacelab Flights (7-Day and 30-Day), during the period 1978 - 1983. Obviously, these curves will require smoothing when implementing manpower planning for support of joint activities. As mentioned earlier, the data on these

curves beyond 1983 is meaningless since the cut off in flight scheduling was at the end of 1985. It should be noted that the scales differ on the curves in this figure such that direct comparison between manning levels for each flight type from this chart is difficult. The important information on this chart is the shape of each individual curve and the information that can be drawn from the variation of resource requirements with time.

Figure 3.3-31, Composite Resources by Joint Activity, All Payloads, 1980-1985 Flights, shows the relative manpower for each activity by month and year as well as the direct comparison between support requirements for each activity since all scales on this chart are the same. This chart provides an excellent indication of the rate of build-up of resources required for each activity and the relationship of the starting times for each of the activities. It will be noted that human resources for training and simulations are not required until 10 months later than activation of the activities for Joint Program/Project Engineering Functions.

Figure 3.3-32, Total Resources, All Flight Types, All Activities, shows a fairly linear build-up in the total manpower resources required for all preflight planning, training and simulations activities after 1978. The average rate of increase in manloading per year between 1979 and 1983 is 1294 man months per year. This equates to an annual increase in professional personnel of about 110 per year over the five year span.

Figure 3.3-32, Total Resources, All Flight Types, All Activities, shows a fairly linear build up in the total professional manpower resources required for all preflight planning, training and simulations activities beginning in 1978 and extending through 1985. An analysis of the curve from 1979 which is the first full year of activities through 1983 reveals the following with regard to total resources required:

a. The total manpower resources required over the five year span is 17,809 man months.

b. The average number of professional personnel required during this period for joint activities is about 300 per year.

c. The average rate of increase in personnel from year to year over this four year period is 110 personnel per year.

3.4 STUDY TASK 3 CONCLUSIONS

The following summarizes the conclusions reached during the study effort associated with Task 3:

a. There are five principal activity areas that involve joint STS and payload participation to prepare for STS-Payload joint flight operations phases - JOINT PROGRAM/PROJECT ENGINEERING FUNCTIONS, SYSTEM SUPPORT, INTEGRATED FLIGHT PLANNING, JOINT OPERATIONS PLANNING AND PROCEDURES DEVELOPMENT, and TRAINING AND SIMULATIONS. These activities are comprised of about 25 major tasks. The tasks further subdivide into an average of 6 or 7 subtasks per task.

b. The total annual resources required during 1978-1983 for joint STS-Payload activities in preparation for joint flight operations are estimated to be:

YEAR	MANMONTHS	PEOPLE
1978	78	6
1979	838	70
1980	2165	180
1981	3337	278
1982	4922	410
1983	6547	546

c. Major break points can be logically identified for applying experience factors to the five principal activities; these were judged to be at Flights 1, 2 and 5 in this study.

d. In allocating prime responsibility for the 25 joint flight preparation tasks to organizations and functional groups, the assignment of all but one task appeared logically to belong either with the SPIDPO (5 tasks) or the MCC-H (19 tasks). The one remaining task, Flight Requirements Development, was judged to be logically a Payload Project Office assignment.

3.5 RECOMMENDATIONS

The following recommendations are made in light of the findings from this study task.

a. In order to determine composite requirements for resources for the STS Operator tasks in long range planning, it is recommended that methodology be used that is similar to that developed in this study task. This would maximize the probability of identifying areas of overlap or gaps in planning activities between the joint operations planners and the unique STS Operator planning.

b. It is recommended that the manning curves be smoothed for practical implementation through the use of:

   (1) Cross training among task performer personnel

   (2) Automation of tasks which require peak manning

   (3) Use of production-line techniques for preflight activities in preparation for flight operations

c. It is recommended that the resources estimates for the joint activities be assessed for impact on the user charge allocations.

d. Joint activities need to be assessed along with similar interfacing activities performed by Payload Operator and STS Operator to further refine the tasks and reduce the manloading requirements. Minimum skill levels required for each task should also be addressed.

e. Consideration should be given to combining the iterative flight planning activities within the same organization where not already done to minimize interfaces and maximize effective interaction.

f. In manpower planning, for staffing the organization responsible for joint flight preparation activities, experience factors should be taken into consideration. The recommended "break points" for application of experience factors occur after Flights 1, 2 and 5 for each activity.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

AEO	Automated Earth Orbiting
C&W	Caution and Warning
EVA	Extra-Vehicular Activities
FCR	Flight Control Room
FO	Flight Operations
FSS	Flight Support System
GSFC	Goddard Space Flight Center
IOM	Integrated Operations Manager
IUS	Interim Upper Stage
IVE	Interface Verification Equipment
JPL	Jet Propulsion Lab
JSC	Lyndon B. Johnson Space Center
LSO	Launch Site Operations
MCC-H	Mission Control Center - Houston
MEM	Module Exchange Mechanism
MLP	Mobile Launch Platform
MMS	Multimission Modular Spacecraft
NOCC	Network Operations Control Center
NOSP	Network Operations Support Plan
NSP	Network Support Plan
NTP	Network Test Plan

ACRONYMS AND ABBREVIATIONS (Concluded)

OFT	Orbital Flight Test
OI	Operational Instrumentation
OPF	Orbiter Processing Facility
PC	Payload Coordinator
PCR	Payload Changeout Room
PDI	Payload Data Interleaver
PGS	Payload Ground Station
PLO	Prelaunch Operations
PMC	Payload Mission Control
POC	Payload Operations Center
POCC	Payload Operations Control Center
PPF	Payload Processing Facility
PRD	Program Requirements Document
PSP	Program Support Plan
RMS	Remote Manipulator System
SAEF	Sterilization, Assembly and Encapsulation Facility
SIRD	Support Instrumentation Requirements Document
SL	Spacelab
SPMS	Special Purpose Manipulator System
SPIDPO	Shuttle Payload Integration and Development Program Office
SPOCC	Standard Payload Operations Control Center
SSUS	Spin Stabilized Upper Stage
STS	Space Transportation System

APPENDIX B

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